Twenty-fourth Annual Report

OF THE

New Jersey State

Agricultural Experiment Station

AND THE

Sixteenth Annual Report

OF THE

New Jersey Agricultural College Experiment Station

FOR THE YEAR ENDING

October 31st, 1903.

SOMERVILLE, N. J.:
The Unionist-Gazette Association, State Printers.
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To His Excellency Franklin Murphy, Governor of the State of New Jersey:

SIR—I have the honor to submit herewith the Twenty-fourth Annual Report of the New Jersey State Agricultural Experiment Station, as required by the law establishing the Station, which was approved March 10th, 1880, and which is chapter CVI. of the laws of that year.

DAVID D. DENISE,
President.

NEW BRUNSWICK, N. J., November 30th, 1903.

To His Excellency Franklin Murphy, Governor of the State of New Jersey:

SIR—In compliance with an act of Congress, approved March 2d, 1887, and with an act of the Legislature of this State, approved March 5th, 1888, I beg leave to submit, on behalf of the Trustees of Rutgers College in New Jersey maintaining Rutgers Scientific School, the New Jersey State College for the benefit of Agriculture and Mechanic Arts, the Sixteenth Annual Report of the operations of that department of the College which has been organized in accordance with said act of Congress, and is known as "The State Agricultural College Experiment Station."

AUSTIN SCOTT,
President.

NEW BRUNSWICK, N. J., November 30th, 1903.

NEW JERSEY AGRICULTURAL EXPERIMENT STATIONS,

NEW BRUNSWICK, N. J.

1. STATE STATION. ESTABLISHED 1880.

BOARD OF MANAGERS.

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EDWARD B. VOORHEES, SC.D., . Professor of Agriculture of the State Agricultural College.

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EDWARD B. VOORHEES, SC.D., . . Director.
IRVING S. UPSON, A.M., . . . Chief Clerk ; Secretary and Treasurer.
MARY A. WHITAKER, ... Stenographer and Typewriter.
IRVING E. QUACKENBOSS, . . Assistant Clerk.

LOUIS A. VOORHEES, A.M., Chief Chemist.
JOHN P. STREET, M.SC., Associate Chemist.
WILLIAM P. ALLEN, B.SC., Assistant Chemist.
VINCENT J. CARBERRY, Assistant Chemist.
GEORGE H. BURTON, Laboratory Assistant.
JOHN B. SMITH, SC.D., Entomologist.
ALVA T. JORDAN., B.SC., Horticulturist.
JACOB G. LIPMAN, PH.D., Soil Chemist and Bacteriologist.
CLARENCE B. LANE, B.SC., Dairy Husbandman.
HARRY W. WILLIAMS, Janitor.

2. AGRICULTURAL COLLEGE STATION. ESTABLISHED 1888.

BOARD OF CONTROL.

The Board of Trustees of Rutgers College in New Jersey.

EXECUTIVE COMMITTEE OF THE BOARD.

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EDWARD B. VOORHEES, SC.D., ... Director.
JULIUS NELSON, PH.D., ... Biologist.
BYRON D. HALSTED, SC.D., ... Botanist and Horticulturist.
JOHN B. SMITH, SC.D., ... Entomologist.
JAMES A. KELSEY, M.SC., ... Field Assistant.
IRVING S. UPSON, A.M., ... Disbursing Clerk and Librarian.
AUGUSTA E. MESKE, ... Stenographer and Typewriter.

THE COLLEGE FARM.

The Trustees of the College give the Stations the use of seven acres of land for experiments in Horticulture and Botany, and the remainder of the farm (90 acres), well stocked and equipped, for experiments in Dairying. The income from the dairy pays for the labor and maintenance of the farm, and in part for dairy experiments.

TREASURER'S REPORT.

Irving S. Upson, in account with the New Jersey State Agricultural Experiment Station, November 1st, 1902, to October 31st, 1903.

APPROPRIATION FOR SALARIES AND EXPENSES.

RECEIPTS.

From State Treasurer	$15,000 00

PAYMENTS.

Salaries and pay of Chemists and Assistants	$10,731 21
Expenses of the Board of Managers	55 18
Stationery	122 72
Printing	186 36
Postage	196 56
Furniture	26 65
Fuel	1,169 11
Gas, Electricity and Water	284 30
Laboratory Expenses	288 99
Field and Feeding Experiment Expenses	858 88
Freight, Express and Cartage	101 25
Expenses Collecting Samples of Fertilizers	246 37
Traveling Expenses	127 81
General Fittings, Repairs and Improvements	281 88
Insurance	199 21
Reference Books	103 69
Contingent Expenses	19 83
	$15,000 00

APPROPRIATION FOR CARRYING OUT THE PROVISIONS OF "AN ACT CONCERNING THE REGULATION OF THE SALE OF CONCENTRATED COMMERCIAL FEEDING STUFFS."

RECEIPTS.

From State Treasurer	$3,000 00

PAYMENTS.

Salaries and pay of Chemists and Assistants	$2,660 00
Laboratory Fittings, Apparatus and Supplies	144 23
Expenses Collecting Samples of Feeding Stuffs	195 77
	$3,000 00

APPROPRIATION FOR PRINTING BULLETINS.

RECEIPTS.

From State Treasurer	$1,500 00

PAYMENTS.

For Printing Bulletins	$1,500 00

APPROPRIATION FOR THE PURPOSE OF CARRYING INTO EFFECT "AN ACT TO PROVIDE FOR AN INVESTIGATION AND REPORT BY THE NEW JERSEY AGRICULTURAL EXPERIMENT STATION UPON THE MOSQUITO PROBLEM, IN ITS RELATION TO THE SANITARY, AGRICULTURAL AND OTHER INTERESTS OF THE STATE."

RECEIPTS.

From State Treasurer	$5,000 00

PAYMENTS.

Salaries and Compensation of Assistants	$2,915 00
Labor	476 04
Postage	41 49
Laboratory and Field Apparatus and Supplies	565 54
Freight and Express	24 70
Traveling Expenses	888 34
Printing	88 89
	$5,000 00

The Auditing Committee of the Experiment Station has examined the accounts of the Treasurer of said Station, and has found them correct.

JOHN E. DARNELL,
GEORGE E. DE CAMP,
Auditing Committee.

FINANCIAL STATEMENT.

THE TRUSTEES OF RUTGERS COLLEGE

FOR

THE NEW JERSEY STATE AGRICULTURAL COLLEGE EXPERIMENT STATION

IN ACCOUNT WITH

THE UNITED STATES APPROPRIATION, 1902–1903.

To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30th, 1903, as per act of Congress approved March 2d, 1887		$15,000 00
By Salaries	$9,730 00	
Labor	901 18	
Publications	1,241 64	
Postage and Stationery	379 53	
Freight and Express	97 48	
Heat, Light and Water	385 57	
Chemical Supplies	80 96	
Seeds, Plants and Sundry Supplies	139 35	
Fertilizers	177 02	
Feeding Stuffs	....	
Library	550 33	
Tools, Implements and Machinery	130 00	
Furniture and Fixtures	100 50	
Scientific Apparatus	191 95	
Live Stock	....	
Traveling Expenses	273 58	
Contingent Expenses	171 00	
Building and Repairs	449 91	
Total		$15,000 00

We, the undersigned duly appointed auditors of the corporation, do hereby certify that we have examined the books and accounts of the New Jersey State Agricultural College Experiment Station for the fiscal year ending June 30th, 1903, that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file, and have been by us examined and found correct, thus leaving no unexpended balance.

And we further certify that the expenditures have been solely for the purpose set forth in the act of Congress approved March 2d, 1887.

Signed, AUSTIN SCOTT,
EDWARD B. VOORHEES,
Auditors.

REPORT OF THE DIRECTOR.

REPORT OF THE DIRECTOR.

The work planned by the Stations for the past year has been practically all accomplished, notwithstanding the loss of time and the inconvenience caused by the burning of the laboratory building on April 23d, 1903. The laboratories and lecture-rooms of the chemical department of the College were also in this building, and the cause of the fire, which originated in the chemical storage-room of the College, could not be ascertained. This room was located in the basement, in the south end of the building, near the tower containing the stairway, to which the fire soon communicated, and thus reached the roof, which was entirely destroyed, together with the laboratories located on the top floor. The damage on the first and second floors was due almost entirely to smoke and water. The building carried an insurance of $35,000, the equipment of the State Station, $3,500, and the equipment of the College Station, $12,000. The sums received under the various policies were $14,681 on the building, $2,226.26 on the equipment of the State Station, and $5,423 on the equipment of the College Station. Contracts have been placed for repairs to the building, the total cost of which does not exceed the amount received, and the building will be practically restored to its former condition. The changes made are mainly in the location of the partitions which separate the different rooms and departments. The new equipment for the various departments will not be purchased until the building is again occupied; the sums received, however, will not be sufficient to fully restore the original equipment. In the State Station the cost of the fire was relatively greater than in the College Station, because it was necessary, in order that the work of analysis might go on, to rent and fit up a laboratory. Fortunately, a building available for the purpose was obtained, and the work of analysis and of investigation was not delayed more than six weeks. The office of the State Station, as well as the offices and laboratories of the College Experiment Station, were, through the generosity of the College, permitted to occupy the Fine Arts building, on the College campus.

Analyses of Commercial Fertilizers.

The method of inspecting fertilizers adopted last year was continued, and has again given great satisfaction, resulting in the completion of the work early in the season and in a fuller representation of the various brands upon the market. The chemists report the analyses of 553 samples, of which 390 are official and represent regular brands upon the market; the remaining consist of raw bone, fertilizing raw materials and miscellaneous products.

As has been the case in previous years, no flagrant adulterations have been discovered, though there are many brands in which wide variations from the guarantee are shown, indicating imperfect or careless methods of manufacture. The cost of manufacture and sale is slightly higher than last year, due, in part, doubtless to the increased cost of labor and other elements of manufacture. The cost of plant-food to the farmer has been slightly higher, due to this increased cost of manufacture, as well as the increased cost of certain of the materials entering into the mixtures.

The most notable improvement in the quality of the goods is in the tendency, which is increasing from year to year, to use soluble forms of nitrogen. In over 50 per cent. of the brands nitrogen was found in the form of nitrate, in 25 per cent. of the brands in the form of ammonia salts, while in 12 per cent. both of these soluble forms were found in quantities exceeding 2.10 per cent. In the case of potash there is no notable increase in the use of sulphate; practically 90 per cent. of the potash is derived from muriate of potash or from kainit. The amount of available phosphoric acid, as well as the per cent. of insoluble, has not changed materially in the past three years. This matter of the form of the constituents is one of very great importance, and the increase in the soluble forms is to be highly commended, and is due, in large part, to the demands of the farmers for high-grade materials, as the law does not require that specific forms of materials shall be used.

The very large number of different brands offered by manufacturers still continues to be a source of confusion and annoyance. It is difficult to understand the necessity for the large number of brands, even from the same manufacturer, that differ so slightly in composition. This matter is controlled, to some extent, in those States in which a brand tax is levied, though it can best be remedied

by the farmers themselves; they should understand the character of plant-food materials sufficiently well to know that the value of a brand does not depend so much upon the proportion of the constituents, as upon the kind, quality and quantity contained in it. That is, that up to a certain point, it is quantity and quality of nitrogen, phosphoric acid and potash, rather than whether there shall be the relation of 1 to 4, or 1 to 2, or any other specific relation between the various constituents. Information upon these points is always contained in the bulletins issued by this Station.

One other point is very strongly emphasized in the work of the chemists this year, and that is the widely varying prices attached to brands carrying practically the same guarantee. It is shown, for example, in a brand guaranteed to contain

Nitrogen	2	per cent.
Phosphoric acid	8	"
Potash	2	"

that the selling price ranges from $20 to $35 per ton; in the case of the highest price per ton the cost of plant-food is 75 per cent. greater than in the other, though no material difference could be expected from their use in the field.

Another point strongly emphasized by the work of the chemists is that brands made up of plain superphosphates and potash salts are, as a rule, very expensive sources of phosphoric acid and potash. Many of these, too, are sold under misleading names, as bone phosphate, either special or dissolved, which are interpreted by the farmers to mean that animal bone is a basis of these materials. In many cases no animal bone whatever has been used, and the grade of the material makes the charges for handling relatively higher than in high-grade goods. It is shown, too, that high-grade goods do, as a rule, furnish the constituents at a much lower price than low-grade materials, to which "make-weight" has been added, and, as a guide to farmers in their purchases, the chemists have devised a simple method of estimating, relatively, the value of brands on the basis of "units." For example, where the goods contain a low percentage of ingredients, and thus a small number of units, the price per unit is much higher than where the mixtures contain a higher percentage of ingredients, or a large number of units, and it is shown, in the case of brands examined this year, that the price per unit is $1.62

for brands guaranteeing nitrogen, 1 per cent., phosphoric acid, 8 per cent., and potash, 2 per cent., and for those guaranteeing nitrogen, 3 per cent., phosphoric acid, 8 per cent., and potash, 10 per cent., the price per unit is $1.18, or a difference of 44 cents per unit in favor of the high-grade goods. These are points of very considerable importance to farmers, for while the difference may not be very great in individual purchases, the aggregate difference is very large, as the amount now paid for fertilizers in the State reaches nearly $3,000,000 annually.

Analyses of Commercial Feeds.

As in previous years, the Station has performed the analyses required in an inspection of concentrated feeds, and, besides the analyses of those which are required by law to be guaranteed, has investigated other feeds, in order to determine the normal variation in the composition of standard products. Wheat middlings were made a special subject of study this year, in order to learn whether the classification usually made by millers is confirmed by actual analysis. The results show that there is a chemical distinction between these various products, and that they are virtually in accordance with the milling distinctions made. The brands examined this year, to determine the accuracy of guarantee, were represented by 233 samples, and the deficiencies were found to be practically the same as last year. Of these but 19 were unaccompanied by a full guarantee, and in 145 cases the guarantees as given were entirely fulfilled. Dairymen and other feeders of the State may, therefore, be congratulated upon the effectiveness of the law providing for a feed inspection, even though the same is yet in the infancy of its operation.

The departure from normal composition of those not requiring guarantee has been due this year to two causes—actual adulteration and to the imperfect preparation of the parts of grain, as, for example, when middlings contain more flour than usual. A study of the results of the work of the year shows that, while there are many innocent contaminations and a few flagrant adulterations, no stock has been found for sale of such a low grade as were obtained last year, when it was deemed necessary to report them in a special bulletin as "Feed Substitutes," which resulted in driving the spurious products from our State.

This work of the chemists is of the very greatest practical usefulness to farmers, not only in educating them in reference to the actual composition of the wide class of by-product feeds, but also in pointing out their use in supplementing home-grown products. As a rule, farm practice, particularly in dairy districts, demands the purchase of protein for the reason that the home-grown products, of which the farmer usually has an abundance, are deficient in that ingredient, and it is important that they should be advised that products low in protein, even though cheap per ton, are not usually advantageously purchased for the purpose of supplying the needed nutrients. Bulletin No. 165 was issued June 15th; it contains full data in reference to the work of the Station in this direction. This bulletin has received a wide circulation, not only in our own State, but has been sent upon request to many farmers, feed dealers and manufacturers in other States. The work of the Station in this direction has also been strongly supported by the various feed trade journals.

Microscopical Examination of Feeds.

In connection with the chemical analyses required in the exercise of the control of commercial feeds, many microscopical examinations have been made for the purpose of determining the presence of, and to identify, foreign substances, as well as to establish the genuineness of various products.

Studies were also made of the changes in the food compounds of corn meal due to the action of mould (Penicillium glaucum), and have shown that, under the proper moisture conditions, the mould causes very large losses of fat, but has very little effect on the protein, ash, fibre and total carbohydrates of the meal. In a parallel test, where the mould was allowed to develop spontaneously, a bacterial growth also appeared. The presence of this growth had an exceedingly harmful effect on the meal, not only causing a very large loss of fat, but also a large loss of albuminoids and carbohydrates.

Chemical Investigations.

In addition to the analyses of fertilizers and feeds required, in order to exercise a proper control of these products, as provided by law, other investigations are carried out which require a large number

of chemical analyses. The most important of these this year are connected with a study of the composition of the limestones of the State, as well as the various lime products offered for sale in the State. This matter has recently assumed great importance, owing to the increased use of lime, as a result of investigations which show the necessity for it, in order that soils may be a good medium for the development of bacterial life; also, because of the increased demands for lime there have been a large number of products placed upon the market, which are claimed to be superior to those usually obtainable, and are sold at a much higher price per ton. It is hoped to have the report of this investigation ready for publication at an early date.

In the plant nutrition experiments, which have been in progress here for the past five years, a large number of chemical analyses are required, as in work of this kind every step in the progress of the experiment must be subject to rigid chemical control. The results that have been obtained thus far in the study of the relative values of nitrogenous substances, as well as the methods which should be used in the handling of farm manures, show very clearly the importance of this line of investigation. The actual losses that occur in the ordinary practice of leaving manure in the open yard are not only enormous in the aggregate, but the value of the residual material is very much reduced. The relative value of the various standard nitrogenous materials is also clearly shown, and a point of great importance developed, namely, that the residual effect of nitrogen in these high-grade products cannot be regarded as of very great importance, though hitherto a large value for these residues has been assumed.

The results of field experiments, as supplementing these investigations, which were carried out to study the effect of the use of nitrate of soda as a top dressing for forage and market garden crops, were incorporated in Bulletin No. 164. This bulletin, which has received a wide circulation, emphasizes very strongly the financial value of a knowledge of the best use of expensive plant-food.

Another investigation, requiring considerable chemical study, and, from the standpoint of the improvement and maintenance of fertility, of greater importance than any other, is that in reference to the accumulation of atmospheric nitrogen in the soil and its utilization by crops. The experiment in progress was planned to determine whether such plants as cow peas were capable of absorbing directly from the air the nitrogen necessary for their growth; whether the

presence in the soil of available forms of nitrogen influenced the absorption of this nitrogen, and whether the nitrogen so gathered in the crop and stored in the soil could be utilized by plants whose sole source of nitrogen is the soil. The results of the first year's experiment show positively that, on soils poor in nitrogen, but well supplied with the mineral elements, the cow pea is capable of acquiring its necessary nitrogen from the air, and that the addition of available forms of nitrogen, as nitrate of soda, sulphate of ammonia, etc., caused the plant to acquire the nitrogen from these sources, rather than from the air, and that the soils so supplied with nitrogen contain less nitrogen after the crop has been removed than those upon which no nitrogen whatever has been applied.

Soil Chemistry and Bacteriology.

The work in this department consisted mainly in the study of nitrogen-fixing bacteria. Considerable study was devoted to the methods of isolation and of the conditions under which the fixation of atmospheric nitrogen may be accomplished in the laboratory. This year a number of nitrogen-fixing organisms were isolated in pure cultures. Of these the most important is an organism of the Azotobacter group, isolated from a Vineland soil. The entire group is new, the first and second members having been isolated by Beijerinck, and the third member (*A. Vinelandii*) was isolated in this laboratory. This organism, together with another nitrogen-fixing organism, also isolated from a Vineland soil, present a very interesting case of symbiotic fixation. Each is capable of fixing atmospheric nitrogen, but in a varying degree.

The soil analyses and bacteriological examinations required in the investigations in plant nutrition, together with the preparation of the results for publication, were performed by the chemist of this department.

DAIRY HUSBANDRY.

The work of this department includes the entire supervision of the work of the farm, which serves, first, as an object lesson in the use of modern methods of dairy farm practice. The farm is, however, divided into acre plots, so that it is possible to study the relative

values of different crops for forage purposes, of different methods of fertilizing and manuring, and of different methods of seeding and the comparative value of different varieties of the same plant.

One of the most important lines of investigation conducted at the farm is the study of the adaptability of alfalfa and of its usefulness as an addition to our regular forage plants. This work has been in progress for six years and a bulletin has been issued on the subject. In view of the apparent advantages of fall seeding, experiments were begun this year to study more particularly methods and times of seeding.

Another line of work begun during the past year is a study of the relative value for forage purposes of different varieties of cow peas and of millet. The data obtained are incorporated in this report, and show strikingly the advantage of work of this sort. It is shown, for example, that the range in yield of cow peas, all seeded at the same time, treated identically and harvested on the same date, was from 6.50 to 10 tons per acre for the different varieties. Inasmuch as the composition of the various varieties is not widely different when the plants are in the best condition for green forage, the tonnage basis is a safe estimate of value, and this experiment shows that the best variety was 54 per cent. better than the poorest. In the case of the millet the relative range in yield was from 1.7 tons per acre to 29 tons per acre. Greater differences in time of maturity were observed in the case of the millet than in the case of the cow peas, the White French maturing the earliest and rapidly losing after maturity, owing to the mechanical losses of seed and to the ravages of birds. Taking the next highest yield, 3.5 tons, which was obtained in the case of the Hungarian and the Red Siberian millets, the range in yield is remarkable, and well worthy of consideration on the part of farmers, who desire to grow this very useful crop.

Economics of dairying also occupy a very important place in the investigations. Data have been obtained for seven years showing the average cost per quart of milk, and it is interesting to note that there is a very close uniformity from year to year. The improvement in methods did not result in materially reducing the cost, owing to the relatively higher prices of feed at the present time.

Studies were also made of the usefulness of home-grown protein crops, as cow pea hay, crimson clover and alfalfa, as substitutes for commercial feeds. The results are of the highest importance, as they show clearly that the farmer has it within his power to grow his own

protein, and that this protein is quite as useful in the nourishment of his animals as that purchased in the concentrated form, making the farm, therefore, the source of all his necessary nutrients, rather than a place where carbohydrates are manufactured, as was formerly believed to be the most economical practice.

Experiments were also conducted to determine whether such concentrated protein feeds as cottonseed meal could be safely used to balance the roughage of the farm, as silage, corn stalks, etc. The results as contained in the body of the report are exceedingly interesting.

HORTICULTURE.

The season throughout was unfavorable for the best growth of fruit and vegetables. The early spring was cold, with late frosts, followed immediately by a long, dry period, and later by excessive moisture conditions and high winds. Good crops, however, were obtained from the small fruits and asparagus. A review of the results to date reveals the importance of the work in progress in this department, and shows forcibly that commercial fertilizers can be successfully used for asparagus and raspberries.

In the tree fruits late frosts did considerable injury, especially to plums and cherries.

Several varieties of apples and pears gave large crops, but differences due to method of treatment are not as yet observable. Peaches produced a fair crop—an exception, as late frosts killed peach buds quite generally throughout the State.

The early applications of nitrate of soda to tree fruits show a marked effect from year to year. The general vigor of the tree is enhanced, resulting in larger yields, with larger fruits, than are obtained where no nitrate is used.

The importance of character of plant in fruit-growing is strikingly shown by the yields obtained with Fay's Prolific currant, and indicates that greater attention should be given to the sources of stock.

Work in the forcing-houses continues to be a study of the use of different fertilizers and of methods of application for such crops as lettuce, cauliflower, cucumbers and tomatoes. Manure has thus far proven superior, on the whole, to any other material used, and some striking results obtained require verification before they are published.

BIOLOGY.

The Biologist has during the past season confined himself almost exclusively to the prosecution of his experimental studies in oyster propagation. Very encouraging progress was made in these studies, which were mainly directed to that period in the life of an oyster embryo which immediately precedes its fixation to cultch. The data and experience secured by the studies this year practically enables the Biologist to prepare an abundance of fry at his will, thus furnishing suitable material for the next step in these studies, viz., the problem of oyster spat fixation.

Near the close of the season an incubator was brought into use, which promises to be an important agent in the success of the work.

Bulletin No. 166, dealing with "The Proper Disposal of Sewerage Wastes in Rural Districts," so as to prevent infection by intestinal parasites, was issued early in the summer. In this bulletin directions were given for properly maintaining the dry earth closet, which method of disposal was considered the best in the absence of a good sewer, and a most efficient means of preventing the contamination (*a*) of drinking water, through undesirable drainage, and (*b*) of food, through the transference of disease germs by flies.

ENTOMOLOGY.

The work of the Entomologist has included, chiefly—first, a study of the insects infesting the asparagus plants; second, a study of leaf-hoppers and their injuries, and third, the preparation of material for a spray bulletin to be based upon conditions as they exist in New Jersey.

Owing to increasing complaints of depredations by certain birds, it was deemed wise to investigate the question of whether the benefits derived by their insectivorous habits counterbalanced the injury done to fruits, under the conditions as they exist in New Jersey. The results of this study are also included as a part of the work of this department. The Chinese Mantid has been fairly established in our State, but to hasten its general distribution over 300 egg masses have been placed in some dozen or more localities from Bergen to Cape May counties. The Asiatic ladybird beetle, which is an enemy to

the San José scale, or pernicious scale, has been kept over at New Brunswick during the winter of 1902–03, and a dozen colonies have been established at as many different points in South Jersey.

The record of the experiment orchard has been continued, chiefly to determine the effects of certain of the insecticides sent in for trial, but also to note the development of such insects as could be best studied there.

Work on the investigation of the mosquito problem has been carried on throughout the season, and a large part of the State has been surveyed for breeding areas. As the study was planned to extend through two years only, a report of progress is made to show in outline what has been accomplished.

BOTANY.

The work in the Botanical Department this year has been chiefly along the lines mentioned in the reports for the past three years.

The breeding of truck crops has held the leading place, and this season has seen the establishment of a new variety of sweet corn, derived from the crossing of "Black Mexican" upon the "Egyptian." A new cross has also been made, taking for the parents the "Black Mexican" and the "Country Gentleman."

In eggplants the cross between the "New York Improved Spineless" and the "Early Long Purple" has become sufficiently fixed to be recognized as a distinct variety, to which the name of "Jersey Belle" has been given.

The breeding of tomatoes has resulted in a sort that has the habit of uprightness in plant and diversity of foliage of its mother parent, the "Dwarf Champion," but with the yellow fruit of its male parent, the "Golden Sunrise." The name of "Station Yellow" has been given to this bushy and otherwise acceptable variety of tomato. Some headway has been made also toward reducing the seediness, but as yet the plants that are thus developed are not productive—that is, the fruits, while with few seeds, are not large or numerous, and are slow in coming to maturity.

Several of the original crossed plants of lima beans have been propagated, and the types are becoming fixed. As these were of the "Burpee" and the "Henderson" combination, they are to be known

as "Burp-Hend" crosses, and each will receive a number, as Burp-Hend No. 1, etc. A variety test was made this season, and on account of the prevalence of mildew it was found that some sorts are much less susceptible than others to this fungus. It was also determined that the mildew much prefers the pole lima to the dwarf sorts.

In the plot of corn, as an accompanying crop, squashes have been grown for a study in crossing, and results were obtained between winter varieties and others between summer sorts, but no crosses were secured between winter and summer kinds of squashes.

The subject of the powdery mildews has received considerable attention as to their number, kinds and distribution and destructiveness in the United States. The season being favorable for the development of the potato rot and diseases of tomatoes, these subjects have received special attention.

Bulletin No. 167, "Some of the Newer Fungicides," was issued by this department during the past year.

FARMERS' MEETINGS.

The officers of the Station have taken an active part in the meetings of farmers throughout the State. The primary purpose of these meetings is the education of the farmer in progressive methods of practice, hence the Station instructors take particular pains to point out the principles which underlie, and to show the progress that has been made in, different departments, and the relation of the work to individual practice. This work has been so successfully carried on in the past that our farmers perhaps receive more direct benefit from the work of the Station than is the case in larger States, where such immediate contact cannot be brought about. This work, of course, requires considerable time, but is believed to be extremely useful in enabling the Station to fulfill its functions.

The Station also serves as a bureau of information, and the correspondence required in the different departments is increasing from year to year, also emphasizing the point already made, that farmers are awakening to the importance of the Station as a source of information on matters pertaining to the farm.

EQUIPMENT.

The policy of the Station in the past has been to supply the various departments with the needful scientific appliances and apparatus; thus new additions are made from year to year, in order that advanced work may be properly prosecuted. Owing to the burning of the laboratory building in April, many valuable pieces of apparatus were injured or destroyed. This has handicapped the work in many departments, as it was not deemed wise to purchase new material until the laboratories could be reinstated in their original quarters.

The library is well supplied with important technical works, standard periodicals and journals, and, fortunately, no great injury to these was caused by the fire. The losses can be readily replaced, and thus complete all of the Station files, which are growing in number and value each year.

REPORT OF THE CHEMISTS.

REPORT OF THE CHEMISTS.

FERTILIZERS.

ANALYSES OF FERTILIZER SUPPLIES, HOME MIXTURES AND SPECIAL COMPOUNDS.

ANALYSES AND VALUATIONS OF COMMERCIAL FERTILIZERS AND GROUND BONE.

1. *Introduction.*
2. *The trade values of fertilizing ingredients for 1903, and the examination of the standard materials supplying them.*
3. *The examination and valuation of home mixtures and special compounds.*
4. *The examination and valuation of manufactured brands and sundry materials.*

1.

INTRODUCTION.

Inasmuch as the amount of work in connection with the fertilizer and feed inspections by this Station is steadily increasing, the demands upon the time of the Station's staff are such as to require concentrated effort upon systematized work. From April 1st to October 1st has been set apart for the examination of fertilizers, and from November 1st to March 1st for the examination of feeds.

The system of inspection was the same this year as last. Mr. W. P. Allen, a regular member of the Station's staff, personally collected practically all of the samples, except a few which were sent in by Granges or individuals. The inspection has been thorough, and twenty of the twenty-one counties of the State were visited and 767 samples

obtained. From among the duplicates of each brand a selection for analysis was made, with the aim that the samples of any one firm should be taken, as far as possible, from different portions of the State, and should represent large stocks of the different brands.

Under certain conditions, however, exceptions to this rule are made, when purchases amounting to twenty tons or more are to be paid for on the basis of actual analysis, or when the analysis will demonstrate a possible development of waste products into cheap sources of plant-food, or in other ways is of general public interest.

The following is a list of those business houses the analyses of whose goods are published in this report:

Manufacturers

WHOSE GOODS HAVE BEEN SAMPLED AND ANALYSED THIS YEAR.

J. H. Allen & Son....................................Lawrence Station, N. J.
American Agricultural Chemical Co............26 Broadway, New York City.
Bradley Branch ....92 State St., Boston, Mass.
Chemical Co. of Canton Branch........32 S. Charles St., Baltimore, Md.
Chicopee Guano Branch...................88 Wall St., New York City.
Clark's Cove Branch.......................81 Fulton St., New York City.
Crocker Branch...........................56 Pearl St., Buffalo, N. Y.
East India Branch.......................93 William St., New York City.
Great Eastern Branch..................................Rutland, Vt.
Milsom Branch.......................963 William St., E. Buffalo, N. Y.
Pacific Guano Branch...................27 William St., New York City.
Packers' Union Branch.................150 Nassau St., New York City.
Moro Phillips Branch......................710 Bourse, Philadelphia, Pa.
Preston Branch.............................Greenpoint, L. I., N. Y.
Quinnipiac Branch.......................83 Fulton St., New York City.
Read Branch.......................16 Exchange Place, New York City.
Sharpless & Carpenter Branch.............710 Bourse, Philadelphia, Pa.
Susquehanna Branch.................................Baltimore, Md.
Tygert-Allen Branch...................2 Chestnut St., Philadelphia, Pa.
Wheeler Branch..Rutland, Vt.
Williams & Clark Branch..............27 William St., New York City.
American Cutlery Co..Keyport, N. J.
Armour Fertilizer Works.....................................Baltimore, Md.
Warren Atkinson..Mullica Hill, N. J.
J. H. Baird..Marlboro, N. J.
Baugh & Sons Co...................20 S. Delaware Ave., Philadelphia, Pa.
H. V. Baxter...Chester, Pa.
The Berg Co.........................Russel and Bath Sts., Philadelphia, Pa.
Berger Bros..Easton, Pa.
John Bower & Co...Philadelphia, Pa.

Bowker Fertilizer Co........................43 Chatham St., Boston, Mass.
Bradley & Green Fertilizer Co....Ninth St. and Girard Ave., Philadelphia, Pa.
Wm. M. Brown..Cedarville, N. J.
E. Frank Coe Co........................133 Front St., New York City.
John S. Collins & Son..................................Moorestown, N. J.
Collins & Pancoast....................................Merchantville, N. J.
A. A. Cortelyou..Neshanic, N. J.
I. S. Curtis..Frenchtown, N. J.
S. V. Davis...Shiloh, N. J.
B. F. Demaris & Son....................................Cedarville, N. J.
Denise & Denise..Freehold, N. J.
J. Y. Dilatush..Robbinsville, N. J.
H. R. Disbrow & Co.....................................Allentown, N. J.
E. S. Dobbs...Mt. Ephraim, N. J.
E. Dougherty..Philadelphia, Pa.
H. W. Doughten...Moorestown, N. J.
Eagle Guano Co...New York City.
Frank Emmons..Newton, N. J.
J. C. Fifield & Sons Co................................Bakersville, N. J.
Fithian & Pennell......................................Bridgeton, N. J.
J. C. Griscom...Woodbury, N. J.
Wm. Harris...Bridgeton, N. J.
Wyckoff Hendrickson....................................Allentown, N. J.
S. M. Hess & Bro................Fourth and Chestnut Sts., Philadelphia, Pa.
Jacob Higgins ....Flemington, N. J.
Ira Hill..Copper Hill, N. J.
Hill & Co..Flemington, N. J.
Hires & Co...Quinton, N. J.
W. B. Hitchner..Woodstown, N. J.
P. Hoffman & Bro.......................................Raullsville, Pa.
International Seed Co..................................Rochester, N. Y.
Hervey Kuhl..Flemington, N. J.
Lackawanna Fertilizer and Chemical Co.......................Moosic, Pa.
Lamberson & Hance.......................................Freehold, N. J.
Samuel Lederer & Sons..............................New Brunswick, N. J.
Joseph Levi..Trenton, N. J.
Lister's Agricultural Chemical Works......................Newark, N. J.
The Mapes F. and P. Guano Co..............143 Liberty St., New York City.
The D. B. Martin Co.............Broad and Chestnut Sts., Philadelphia, Pa.
R. C. Maurer...Elizabethport, N. J.
V. O. Miller...South Dennis, N. J.
John E. Minch...Bridgeton, N. J.
Mitchell Fertilizer Works.................................Tremley, N. J.
Mixner & Mickel...Bridgeton, N. J.
Monmouth Fertilizer Works..............................Shrewsbury, N. J.
E. Mortimer & Co...New York City.
J. R. Moore..Swedesboro, N. J.
L. Moritz........................1321 North Fifth St., Philadelphia, Pa.
Nassau Fertilizer Co.........................5 Beaver St., New York City.
National Fertilizer Co..................................Bridgeport, Conn.
Albert Nelson & Co......................................Allentown, N. J.
New Jersey Agricultural Chemical Co........................Newark N. J.

Newport Fertilizer Co....................407 Drexel Bldg., Philadelphia, Pa.
James E. Otis...Tuckerton, N. J.
S. L. Pancoast..Mullica Hill, N. J.
Peterson & Smith......................................Woodstown, N. J.
Pittsburg Provision Co................................Herr's Island, Pa.
R. H. Pollock.............................51 S. Gay St., Baltimore, Md.
Quaker City Poudrette Co...............19 N. Juniper St., Philadelphia, Pa.
John Repp ....Glassboro, N. J.
Enos Richmond...Elmer, N. J.
Edward Rigg, Jr.......................................Burlington, N. J.
M. F. Riley...Elmer, N. J.
Ruckman Bros.....................................New Brunswick, N. J.
Scott Fertilizer Co...Elkton, Md.
Sharpless & Bro..Camden, N. J.
J. E. Sherman...Frenchtown, N. J.
M. L. Shoemaker & Co......Delaware Ave. and Venango St., Philadelphia, Pa.
L. W. Sickler..Glassboro, N. J.
Jos. Smith & Co...Stockton, N. J.
Rufus W. Smith..Elmer, N. J.
Taylor Bros..Camden, N. J.
The Taylor Provision Co...................................Trenton, N. J.
I. P. Thomas & Son Co................2 S. Delaware Ave., Philadelphia, Pa.
Trenton Bone Fertilizer Co................................Trenton, N. J.
F. W. Tunnell & Co.........................15 N. Fifth St., Philadelphia, Pa.
The J. E. Tygert Co..................28 S. Delaware Ave., Philadelphia, Pa.
J. E. Tygert & Son.........................2 Chestnut St., Philadelphia, Pa.
Vineland Grain Co...Vineland, N. J.
J. K. Waddington..Salem, N. J.
Emil Wahl Manufacturing Co..............3870 Pulaski Ave., Nicetown, Pa.
Geo. M. Wells...Moorestown, Pa.
J. Wenderoth & Sons..Camden, N. J.
West Jersey Marl and Transportation Co.......................Sewell, N. J.
William Wilde...Vineland, N. J.
Winterbottom, Carter & Co............................Egg Harbor City, N. J.
Henry Wise...Philadelphia, Pa.
I. S. Yarnall...Media, Pa.

The inspection of fertilizers this year has required the following analyses:

390	samples of	Complete Commercial Mixtures.
24	" "	Incomplete Commercial Mixtures.
34	" "	Ground Bone.
67	" "	Fertilizing Raw Materials.
6	" "	Home Mixtures.
25	" "	Specially Compounded Mixtures.
7	" "	Sundry Materials.
553		

2.

THE TRADE VALUE OF FERTILIZING INGREDIENTS FOR 1903.

The estimated commercial value of fertilizers is separate and distinct from the agricultural value. The latter depends upon the character and form of the materials, with reference to their availability, and the needs and value of the crop for which they are to be applied. The former, on the other hand, is determined by market and trade conditions, such as supply and demand, the cost of production, etc., and is derived by applying to the various forms of plant-food ingredients, as shown by analysis, the values previously determined upon for them. These values are fixed from year to year, and are altered according to the cost of the standard materials containing these forms of plant-food, as shown in market reports and actual transactions.

The wholesale prices of crude products, or raw materials, are quoted every Monday in the well-known trade journal, *The Oil, Paint and Drug Reporter*. These prices have been tabulated for the entire year, and have then been recalculated, in order to express them as prices per pound of actual plant-food, which is the form adopted by the Experiment Stations of this country. The recalculation has been made upon the basis of the following analyses:

Nitrate of Soda	16	per cent.	Nitrogen.
Sulphate of Ammonia	20½	"	"
Dried Blood	12½	"	"
Acid Phosphate	12	"	Available Phosphoric Acid.
High-Grade Sulphate of Potash	50	"	Potash.
Double Sulphate of Potash and Magnesia,	25	"	"
Muriate of Potash	50	"	"
Kainit	12½	"	"

On account of the fact that the report of the Experiment Station is made up on October 30th of each year, the results which appear in tabular form are for the year 1902. During that year the prices of the nitrogen-furnishing materials fluctuated somewhat, becoming stronger toward the close of the year. As it is probably at this time that the manufacturers of mixed goods place their contracts for raw materials, the quotations for the last four months of 1902 and the first two months of 1903 have been averaged as a more suitable basis for the determination of the schedule of valuations for 1903.

Wholesale Cost, Per Pound, in New York—

MONTHS.	OF NITROGEN IN FORM OF—						OF PHOSPHORIC ACID IN FORM OF—		OF POTASH IN FORM OF—							
	NITRATE OF SODA.		SULPHATE OF AMMONIA.		DRIED BLOOD.		ACID PHOSPHATE.		KAINIT.		MURIATE OF POTASH.		DOUBLE SULPHATE OF POTASH AND MAGNESIA.		HIGH-GRADE SULPHATE OF POTASH.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.	cts.
January	12.6	12.5	13.9	13.8	13.8	13.5	3.3	3.0	3.7	3.5	3.7	3.7	4.6	4.5	4.3	4.2
February	14.1	13.8	14.5	14.3	13.7	13.4	3.3	3.0	3.7	3.5	3.7	3.7	4.6	4.5	4.3	4.2
March	14.6	14.5	14.5	14.4	14.0	13.9	3.3	3.0	3.7	3.5	3.7	3.7	4.6	4.5	4.3	4.2
April	15.5	15.0	14.9	14.7	14.6	14.3	3.3	3.0	3.7	3 5	3.7	3.7	4.6	4.5	4.3	4.2
May	13.9	13.5	15.1	14.9	15.0	14.7	3.3	3.0	3.7	3 5	3.7	3.7	4.6	4.5	4.3	4.2
June	13.5	13.2	15.3	15.1	14.6	14.3	3.3	3.0	3.7	3.5	3.7	3.6	4.5	4.4	4.3	4.2
July	12.9	12.5	14.9	14.7	14.3	14.0	3.3	3.0	3.7	3.5	3.7	3.6	4.5	4.4	4.3	4.2
August	12.0	11.7	14.6	14.0	14.4	14.1	3.3	3.0	3.7	3.5	3.7	3.6	4.5	4.4	4.3	4.2
September	11.9	11.8	15.0	14.7	14.7	14.5	3.3	3.0	3.7	3.5	3.7	3.6	4.5	4.4	4.3	4.2
October	11.9	11.8	14.6	14.4	15.2	15.2	3.3	3.0	3.7	3.5	3.7	3.6	4.5	4.4	4.3	4.2
November	12.3	12.2	14.5	14.4	14.8	14.8	3.3	3.0	3.7	3.5	3.7	3.6	4.5	4.4	4.3	4.2
December	12.8	12.5	14.9	14.7	14.8	14.8	3.3	3.0	3.7	3.5	3.7	3.6	4.5	4.4	4.3	4.2
Average for 1902	13.0		14.6		14.4		3.1		3.6		3.7		4.5		4.2	
Average for 1901	11.8		13.5		14.0		3.1		3.6		3.7		4.5		4.2	
Average for 1900	11.6		14.2		14.0		3.2		3.7		3.7		4.2		4.1	

The wholesale prices per pound of plant-food prevailing in New York during the six months immediately preceding March 1st last were for nitrogen in nitrate of soda, 12.2 cents; in sulphate of ammonia, 14.9 cents, and in high-grade dried blood, 15.2 cents; for available phosphoric acid in acid phosphate, 3.1 cents; and for actual potash in muriate of potash, 3.7 cents, in kainit, 3.6 cents, in double sulphate of potash and magnesia, 4.4 cents, and in high-grade sulphate of potash, 4.2 cents. A comparison of these figures with those of last year will show that there have been decided advances in the market prices of sulphate of ammonia and dried blood, while the prices of acid phosphate and the potash salts show little change.

From these wholesale prices, as a basis, the following schedule of trade values was arranged at a meeting of Station Directors and Chemists for use in Connecticut, Massachusetts, New York, Rhode Island, Vermont and New Jersey during the season of 1903:

Schedule of Trade Values Adopted by Experiment Stations for 1903.

	Cents per pound.
Nitrogen in Nitrates	15.0
" " Ammonia Salts	17.5
Organic Nitrogen in dried and fine-ground fish, meat and blood, and in mixed fertilizers	17.0
" " " fine-ground bone and tankage	16.5
" " " coarse bone and tankage	12.0
Phosphoric Acid, soluble in water	4.5
" " " " ammonium citrate*	4.5
" " insoluble in fine bone and tankage	4.0
" " " " coarse bone and tankage	3.0
" " " " mixed fertilizers	2.0
" " " " fine-ground fish, cotton-seed meal, castor pomace and wood ashes	4.0
Potash as Muriate	4.25
" " Sulphate, and in forms free from muriates (or chlorids),	5.0

* The solubility of phosphates, in ammonium citrate solutions, varies with the degree of heat. An act of the Legislature (see Laws of New Jersey, 1874, page 90), provides that in this determination the temperature used shall not exceed 100° Fahr.; in other States 150° Fahr. has been adopted. Consequently the Station valuation of phosphoric acid, soluble in ammonium citrate has been fixed at *four cents* per pound for Connecticut, Massachusetts, New York, Rhode Island and Vermont, and at *four and one-half cents* per pound for New Jersey.

The Examination of Unmixed Fertilizing Materials.

The results of the analysis of sixty-six samples of standard unmixed raw materials appear in tabulated form upon subsequent pages. This work is of particular value in that it directs the attention of the consumer to the composition and use of standard fertilizing supplies, and suggests rational and economical methods of purchasing plant-food. The samples include nitrate of soda, sulphate of ammonia, dried blood, dried and ground fish, tankage, acid phosphate, muriate and sulphate of potash and kainit. With few exceptions the analyses indicate that the materials were of good quality, although the usual wide variations are shown in the case of blood, fish and tankage. Since the samples represent goods actually on the market at the prices given, the average cost per pound of their several ingredients may be fairly assumed to represent the average prices charged for nitrogen, phosphoric acid and potash by different manufacturers. These average prices are 14.4 cents per pound for nitrogen in nitrate of soda, 15.7 cents in sulphate of ammonia, 19.1 cents in dried blood, 15.4 cents in tankage, and 18.2 cents in dried and ground fish; 3.7 cents per pound for available phosphoric acid in acid phosphate, and 4.2, 5 and 4.3 cents per pound for actual potash in muriate of potash, sulphate of potash and kainit, respectively.

The raw materials on the average were, therefore, secured somewhat lower than the Station's prices, the principal exceptions being dried blood and dried fish, which were very expensive forms of organic nitrogen this year; the greater number of the samples of these materials, however, were dealers' samples, and were sold in the same way, and, to a degree, with the same profits as complete fertilizers, thus explaining their comparatively high prices.

3.

THE EXAMINATION OF HOME MIXTURES AND SPECIAL COMPOUNDS.

The analyses of six home mixtures and of eighteen special mixtures are published herewith. In certain of the latter merely the guaranteed analysis, which is given in the tables, was required of the manufacturer; in others the use of certain ingredients was insisted upon. The ingredients of the home and special mixtures reported to us were as follows:

Composition.

Home Mixtures.

No. 3152.
200 lbs. Nitrate of Soda.
200 " Ammonite.
300 " Tankage.
400 " Dissolved Bone.
600 " Acid Phosphate.
300 " Sulphate of Potash.

No. 3476.
100 lbs. Nitrate of Soda.
100 " Acid Phosphate.
100 " Kainit.

No. 3024.
200 lbs. Nitrate of Soda.
300 " Muriate of Potash.
Balance, Bone, Tankage, etc.

No. 3757.
250 lbs. Nitrate of Soda.
500 " Dried Blood.
800 " Bone Black.
450 " Muriate of Potash.

No. 3758.
250 lbs. Nitrate of Soda.
500 " Dried Blood.
400 " Acid Phosphate.
850 " Wood Ashes.

No. 3337.
200 lbs. Nitrate of Soda.
100 " Sulphate of Ammonia.
100 " Dried Blood.
500 " Steamed Bone.
800 " Acid Phosphate.
400 " Muriate of Potash.

Special Mixtures.

No. 3583.
100 lbs. Nitrate of Soda.
150 " Acid Phosphate.

No. 3765.
500 lbs. Tankage.
1,300 " Acid Phosphate.
200 " Muriate of Potash.

The following table shows the average composition of the home and special mixtures, together with their average value and cost, and the difference between the same:

	Total Nitrogen.	Total Phos. Acid.	Available Phos. Acid.	Insoluble Phos. Acid.	Potash.	Station's Valuation.	Selling Price or Cost.	Difference Between Valuation and Selling Price.	Percentage Difference.
	%	%	%	%	%				
Home Mixtures...	3.62	8.80	7.26	1.54	7.11	$24 86	$26 37	$1 51	6.07
Special Mixtures..	1.99	11.23	9.07	2.16	6.70	21 64	22 67	1 03	4.76

The average cost, therefore, of the home and special mixtures was $1.27 more than the valuation, or 5.46 per cent., while the excess of selling price over valuation in the case of the complete fertilizers examined this year, as will be seen later, was $7.07, or 34.5 per cent.

4.

THE EXAMINATION AND VALUATION OF MANUFACTURED BRANDS AND SUNDRY MATERIALS.

The object of this, the main fertilizer work of the Station, is to determine by chemical analysis whether the *actual* composition of each of the various manufactured products corresponds with its *guaranteed* composition, as required by law, whereby it is shown whether the material fulfills the claims of the manufacturer and to what degree the guarantee given is a guide to the amounts of plant-food delivered to the consumer. In addition, the application of the schedule of values for the several forms of plant-food, as given on a previous page, gives relatively the manufacturing or first cost of the individual brands, which may be directly compared with the selling prices to show the charges of the manufacturer for mixing, bagging and other expenses in effecting their sale.

This work is of twofold value:—*direct,* in that it furnishes the shrewd and experienced purchaser with information as to the composition and cost of the brands to which his attention may be drawn; and *indirect,* in its restraining influence, whereby worthless material is practically kept away from our markets.

1. Complete Fertilizers.

The number of samples of complete fertilizers, whose analysis is herewith reported, is 390, practically the same as last year and eighty-two more than in 1901. These 390 brands are the product of 101 establishments, if the branches of the American Agricultural Chemical Company be considered separately. The number of manufacturers represented is constantly increasing, there being six more this year than in 1902, and twenty-two more than in 1901. The average number of brands per manufacturer this year is three and eight-tenths,

somewhat smaller than last year. There are seventy-four manufacturers each represented by four or less, eighteen by from five to eight (twice the average), six by from nine to twelve (three times the average), and three by from fourteen to seventeen brands (four times the average). The extent to which the multiplication of brands is carried in some cases would seem to be in excess of that needed for a range of choice, especially as in many cases the differences are practically in name only. Seventy-one per cent. of the brands analysed are put on the market by ninety-two manufacturers, each supplying from one to eight brands; the remaining 29 per cent. of the brands are supplied by nine manufacturers, with from nine to seventeen brands apiece. It is difficult to understand why the trade requirements should be more exacting for these nine manufacturers than the other ninety-two. The claim that this multiplicity of brands is required by the demand for fertilizers for special crops would seem to be unwarranted, as there is practically little agreement among the manufacturers as to these requirements, while, in certain cases, the same brands are designated for potatoes, tomatoes, cabbage, tobacco, hops, corn, onions, vines, vegetables, early truck, general truck and general use. One hundred and twenty of the complete fertilizers examined were designated as potato manures, with sixty-four different guarantees, ranging from 1 to 5 per cent. ammonia, 4 to 10.5 per cent. available phosphoric acid and 2 to 12 per cent. potash. The necessity may, therefore, be readily seen of the requirement by law of the printed statement of the guaranteed composition of each brand.

Guarantees and Actual Composition.

With one exception, every brand examined this year was accompanied by a guarantee, as required by law. Over one-third of the samples are defective in respect to phosphoric acid, either available or total phosphoric acid alone being guaranteed.

A careful comparison of the analysis of each brand with its accompanying guarantee shows that about 37 per cent. are deficient in one or more of the plant-food elements. The deficiencies, compared with those of the past eight years, are shown in the following tabulation, in which deficiencies in nitrogen of 0.20 per cent. and in phosphoric acid and potash of 0.30 per cent. have been ignored:

YEAR.	Number of Brands.				Deficiencies possible.	Actual Deficiencies.			
	Examined.	Found as guaranteed.	Found deficient.	Percentage deficient.		Nitrogen.	Phosphoric Acid.	Potash.	Percentage.
1895	269	158	111	41	807	17	72	37	15.6
1896	329	211	118	36	987	30	52	56	14.0
1897	284	194	90	32	852	29	47	30	12.4
1898	303	201	102	34	909	43	29	49	13.3
1899	321	222	99	31	963	33	51	32	12.0
1900	298	214	84	29	894	33	35	31	11.1
1901	308	202	106	35	924	31	60	34	13.5
1902	391	269	122	31	1,173	44	54	49	12.5
1903	390	246	144	37	1,170	83	47	52	15.6

As indicated in the table, there are 182 deficiencies, distributed among 144 brands, twenty-eight brands being deficient in two particulars and five brands in all three ingredients. As there is a total of 1,170 deficiencies possible in the 390 brands examined, it follows that 15.6 per cent. of these possibilities have actually occurred. This percentage would be still larger were it not for the allowance of 0.20 and 0.30 per cent. referred to, whereby many brands would be classed as deficient besides those stated above. On the other hand, certain brands, by their analysis, give evidence of poor mixing, rather than of intentional inferiority. An examination of the tables shows that in sixty-five brands classed as deficient in one or more ingredients, the deficiency is balanced by an excess in one or both of the other ingredients; seventy-nine brands, or 20 per cent., therefore, remain which are deficient in the total plant-food guaranteed. The deficiencies do not seem to be limited to any one class of goods, both low-priced and high-priced brands, in certain cases, failing to reach their guarantees.

Station's Valuations and Selling Prices.

The Station's valuation per ton is derived by applying to the different constituents the schedule of prices already given them; it is intended to show the retail cash cost of the amount of nitrogen, phosphoric acid and potash contained in one ton if they were bought at factory in the form of raw materials, unmixed. The difference between selling price and Station's value shows, therefore, the charge that is made for mixing, bagging, shipping and *selling* the several brands.

The selling price per ton entered in the table is the price at the point where sampled. These prices differ in the various localities of the State, due mainly to differences in freight rates from point of production to consumers' depot, the amount sold and commission charged. Nothing has been added to the valuations to represent these charges, the Station preferring to let the consumer make such calculations himself, whereby they will apply to his own conditions.

The average composition, estimated value and selling price of all of the brands of complete fertilizers examined each year for the past thirteen years, together with the actual and the percentage difference by which the selling price exceeds the valuation, are shown in the following tabulation:

YEAR.	Total Nitrogen.	Total Phos. Acid.	Available Phos. Acid.	Insoluble Phos. Acid.	Potash.	Station's Valuation.	Selling price.	Actual difference.	Percentage difference.
1891	2.71	10.12	7.29	2.83	4.21	$25 31	$34 23	$8 92	35.2
1892	2.74	10.38	7.70	2.67	4.50	25 66	34 19	8 53	33.2
1893	2.69	10.23	7.54	2.69	4.58	24 41	34 11	9 70	39.7
1894	2.87	10 40	7.37	3.03	4 94	24 83	34 17	9 34	37.6
1895	2.80	10.74	7.84	2.90	4.80	24 15	32 87	8 72	36.1
1896	2.51	10.86	8 21	2 65	5.02	21 70	30 33	8 63	39.8
1897	2.54	10.93	8.01	2.91	5.01	21 58	29 28	7 70	35.7
1898	2.45	10.69	8.37	2.32	5.38	19 90	28 58	8 68	43.6
1899	2 41	10.58	8.27	2.31	5.67	19 95	27 75	7 80	39.1
1900	2.30	11.03	8.44	2.59	5.89	20 77	27 26	6 49	31.2
1901	2.31	10.48	8.08	2.40	5.77	21 19	27 31	6 12	28.9
1902	2.38	10.47	8.09	2.38	5.32	21 32	27 66	6 34	29.7
1903	2.27	10 52	8.15	2.37	5.49	20 50	27 57	7 07	34.5

The average composition of the complete fertilizers differs but little from that of the past few years; the amount of phosphoric acid is practically the same, while there is a slight loss in nitrogen and a slight gain in potash. The quality of the goods was generally excellent; the tendency, noticed in previous years, towards an increased use of the water-soluble forms of nitrogen is equally marked this year. In 208 brands nitrogen was found in the form of nitrates and in ninety-eight brands in the form of ammonia salts, while in forty-five brands both of these soluble forms of nitrogen were found in quantities exceeding 0.20 per cent. Seven-tenths of one per cent., or about one-third, of the total nitrogen was in the water-soluble form. In the case of potash only forty brands were found in which the chlorides present indicated the use of sulphate of potash, and these were limited to a few manufacturers; the great bulk of the potash, over 90 per cent., is derived from muriate of potash or kainit.

The advance in cost of ammoniates last spring was met by increases in the Station's schedule of valuations. It is of interest, therefore, to calculate the average valuation for the past two years by means of the same schedule. Using last year's schedule, the valuations, compared with the selling prices, are shown as follows:

	Station's Valuation.	Selling Price.	Actual Difference.
1902	$21 32	$27 66	$6 34
1903	21 17	27 57	6 40

It appears, therefore, that the manufacturers are delivering, on the average, a little less total plant-food than in 1901, at a slightly lower price per ton.

The difference between the average valuation and selling price, however, is $7.07 per ton, considerably greater than in any year since 1899; this difference represents the average charge of the manufacturers for mixing and bagging an average of $20.50 worth of plant-food and for dealers' commissions and other expenses incurred in effecting its sale and delivery. This is 34.5 per cent. of the value delivered. That this average charge is not made in all cases is shown in the following tabulation:

Selling price from	0 to 10	per cent. over valuation	.. 21	brands.
" " "	11 " 20	" " " "	.. 54	"
" " "	21 " 30	" " " "	.. 79	"
" " "	31 " 40	" " " "	.. 80	"
" " "	41 " 50	" " " "	.. 69	"
" " "	51 " 60	" " " "	.. 45	"
" " "	61 " 70	" " " "	.. 19	"
" " "	71 " 100	" " " "	.. 21	"
" " more than	100	" " " "	.. 2	"

Thus it is seen that in 154, or 40 per cent., of the brands the difference was less than 30 per cent.; in eighty, or 20 per cent., it equalled the average, while in 156, or 40 per cent., it ranged from 41 per cent. to a maximum of 134 per cent. These facts strongly emphasize the importance of a strict consideration on the part of the consumer of the relation of the guarantee to the selling price of the brands purchased. Forty per cent. of the brands on the market this year, at the prices asked, were cheap sources of plant-food; 20 per cent. occupy an intermediate position, while the remaining 40 per cent. were sold at such a high price that methods of economy would forbid their purchase.

It has been frequently observed by this Station that brands carrying the same guarantee often vary widely in selling price. To emphasize this point the following table has been prepared, where the maximum and minimum valuation and selling price of brands of each of the different guarantees is given. The term "unit" in this table means units of plant-food furnished by the guarantee, based on the valuation of the different ingredients; 1 per cent. of ammonia is counted as three units, and 1 per cent. of available phosphoric acid and potash each as one unit. No account is taken of the form of the nitrogen, nor of the insoluble phosphoric acid; the latter is practically constant for all guarantees. As a rule, the higher-grade brands carry more water-soluble nitrogen, and if this had been allowed for in the table the results would have been even more striking. The tenth and eleventh columns of the table show the average valuation and selling price of one unit of plant-food as guaranteed. A few brands which varied widely from their guarantee were omitted.

Comparison of Valuation and Selling Price for Different Guarantees.

No. of Units.	No. of Samples.	VALUATION. High.	VALUATION. Low.	VALUATION. Average	SELLING PRICE. High	SELLING PRICE. Low.	SELLING PRICE. Average.	Percentage Excess of Selling Price over Valuation.	Valuation per Unit.	Selling Price per Unit.	Excess of Selling Price over Valuation per Unit.	TYPICAL GUARANTEE. Ammonia.	TYPICAL GUARANTEE. Available.	TYPICAL GUARANTEE. Potash.
								%				%	%	%
10	1	$9 94	$9 94	$9 94	$18 50	$18 50	$18 50	86.1	$0 99	$1 85	$0 86	½	7	1½
11	12	13 30	7 09	11 45	20 25	16 60	18 86	64.7	1 04	1 71	0 67	1	7	1
12	6	16 63	11 84	13 65	22 00	17 00	20 17	47.8	1 14	1 68	0 54	1	8	1
13	14	15 88	10 69	13 48	24 00	17 00	20 07	48.9	1 04	1 54	0 50	1	8	2
14	18	22 36	12 99	15 39	32 00	20 00	23 42	52.2	1 10	1 67	0 57	1	8	3
15	20	19 33	12 94	15 30	28 00	18 50	22 35	46.1	1 02	1 49	0 47	2	8	1
16	30	22 78	13 03	16 44	35 00	20 00	23 83	44.9	1 03	1 49	0 46	2	8	2
Average......		....	....	13 66	....	....	21 03	55.8	1 05	1 62	0 57	1	8	2
17	22	19 89	15 58	17 32	30 00	20 00	24 59	42.0	1 02	1 45	0 43	2	8	3
18	16	21 20	14 70	17 66	28 00	21 00	24 78	40.3	0 98	1 38	0 40	2	8	4
19	25	24 81	16 72	19 39	30 00	23 00	25 83	33.2	1 02	1 36	0 34	2	8	5
20	11	21 19	17 93	19 54	32 00	25 00	27 59	41.2	0 98	1 38	0 40	2	9	5
21	22	24 14	17 42	20 74	37 50	23 00	28 60	37.9	0 99	1 36	0 37	2	9	6
22	16	24 07	17 02	20 45	40 00	24 00	28 38	38.8	0 93	1 29	0 36	3	8	5
23	23	25 91	16 62	22 16	36 00	25 00	29 12	31.4	0 96	1 27	0 31	3	9	5
Average......		....	....	19 61	....	....	26 98	37.8	0 98	1 36	0 38	2	9	5
24	34	25 29	18 60	22 66	40 00	25 00	29 46	30.0	0 94	1 23	0 29	3	8	7
25	10	27 55	22 30	24 24	33 00	27 00	30 19	24.5	0 97	1 21	0 24	3	6	10
26	12	25 76	23 06	24 36	36 00	26 00	30 82	26.5	0 94	1 19	0 25	3	7	10
27	31	28 11	21 41	25 26	40 00	27 00	32 01	26.7	0 94	1 19	0 25	3	8	10
28	14	28 61	24 14	26 33	40 00	28 00	32 66	24.0	0 94	1 17	0 23	4	8	8
29	17	29 32	24 47	27 12	39 00	28 00	31 70	16.9	0 94	1 09	0 15	4	8	9
30	4	32 24	26 41	28 68	42 00	30 00	36 00	25.5	0 96	1 20	0 24	4	8	10
Average......		....	....	25 52	....	....	31 83	24.9	0 95	1 18	0 23	3	8	10
31	7	28 40	27 57	27 94	34 00	30 00	31 86	14.0	0 90	1 03	0 13	4	9	10
32	4	31 37	28 12	29 45	38 00	31 00	34 00	15.4	0 92	1 06	0 14	5	8	9
33	2	30 24	28 48	29 36	38 00	34 00	36 00	22.6	0 89	1 09	0 20	5	8	10
35	1	33 21	33 21	33 21	41 00	41 00	41 00	23.5	0 95	1 17	0 22	6	8	9
38	2	35 31	33 55	34 43	43 00	36 00	39 50	14.7	0 91	1 04	0 13	7	8	9
39	2	34 53	34 30	34 42	47 00	37 00	42 00	22.0	0 88	1 08	0 20	10	5	4
Average......		....	....	31 47	....	....	37 39	18.7	0 91	1 07	0 16	6	8	9

In order not to make the comparison along too narrow lines the guarantees have been grouped into four classes, those containing from ten to sixteen units of plant-food, typified by the guarantee of one ammonia, eight available and two potash; those containing from seventeen to twenty-three units, with an average guarantee of two, nine, five; those containing from twenty-four to thirty units, with an average guarantee of three, eight, ten, and those containing from thirty-one to thirty-nine units, with an average guarantee of six, eight, nine.

The very wide variations between the valuations and selling prices of brands of the same guarantee are very striking. In class 1 the valuation varies from $22.78 to $9.94, the greatest variation in any individual group being $9.75, with sixteen units; the selling price of this same class varies from $35 to $16.60, the greatest difference, $15, again being observed with sixteen units. In class 2 the valuation varies from $25.91 to $14.70, the greatest difference, $9.29, being with twenty-three units; the selling price varies from $40 to $20, the greatest difference, $16, being with twenty-two units. In class 3 the valuation varies from $32.24 to $18.60, the greatest difference, $6.70, being with twenty-seven units; the selling price varies from $42 to $25, the greatest difference, $15, being with twenty-four units. In class 4 the valuation varies from $35.31 to $28.40, the greatest difference, $3.25, being with thirty-two units; the selling price varies from $47 to $30, the greatest difference, $10, being with thirty-nine units. It is evident at once, therefore, that there are very wide variations in the amounts of plant-food furnished under the same guarantee and even greater variations in the prices asked. While there is considerable variation in the guaranteed units in the different classes, an inspection of the table will show that almost as great variations are found in nearly every individual group, although these variations, as a rule, become less as the grade of the goods is raised. The above consideration indicates very clearly the necessity of the consumer comparing carefully the guarantee of the brand with the price asked for it. It will be found that "shopping" in the purchase of fertilizers may be practiced, as a rule, with even greater advantages than in the case of ordinary household supplies.

The above table illustrates another very important point of great practical interest to all consumers of complete fertilizers, namely, the relative cost of high and low-grade goods. Grouping the guarantees

in four classes, as above, it is found that the average valuation in class 1 is $13.66, the selling price, $21.03, and the average excess of the latter, 55.8 per cent. In class 2, valuation, $19.61, selling price, $26.98, excess, 37.8 per cent. In class 3, valuation, $25.52, selling price, $31.83, excess, 24.9 per cent. In class 4, valuation, $31.47, selling price, $37.39, excess, 18.7 per cent. It will be observed that there is a regular decrease in the difference between valuation and selling price as the guarantee increases; in general, the lower grade goods are the more expensive.

The table also shows the variation in valuation and selling price per unit for the different classes. In class 1 the selling price per unit exceeds the valuation by 57 cents, in class 2 by 38 cents, in class 3 by 23 cents, and in class 4 by 16 cents; the same steady decrease is noticed as the grade of the goods increases.

To summarize, the Station urges the consumer, not only to carefully scrutinize the guarantee, but also to compare it carefully with the selling price asked. Further, it is again called to the attention of the consumer that, in the purchase of low-grade fertilizers, not only is there a possibility of materials of an inferior grade being furnished, but that for these brands he will pay higher relative charges for mixing, bagging, commissions, etc., than in the case of high-grade fertilizers. In other words, the low-priced fertilizer is not always the cheap fertilizer; the relation between guarantee and selling price is ever of prime importance.

FORMS OF NITROGEN.

Readily and Completely Soluble in Water.

Station Number.	FROM WHOM RECEIVED.	Percentage of Nitrogen.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Material.
	Nitrate of Soda.	%	cts.	
3008	W. M. Perrine, Hightstown	15.51	14.18	$44 00
3018	J. S. Collins & Son, Moorestown	15.66	14.37	45 00
3195	J E. Minch, Bridgeton	15.66	15.97	50 00
3269	College Farm, New Brunswick	15.91	14.14	45 00
3299	Fruit Growers' Union, Cologne	15.91	15.71	50 00
3502	Lamberson & Hance, Freehold	15.85	13.41	42 50
3612	J. W. Pincus, Woodbine	16.03	13.10	42 00
	Average Cost per Pound	....	14.41	
	Sulphate of Ammonia.			
3526	J. H. Baird, Marlboro	20.72	15.68	65 00

FORMS OF NITROGEN INSOLUBLE IN WATER.

Station Number.	FROM WHOM RECEIVED.	Percentage of Nitrogen.	Percentage of Phosphoric Acid.	Cost of Nitrogen per lb.	Cost of 2,000 lbs. of Material.
	Dried Blood.	%	%	cts.	
3009	W. M Perrine, Hightstown	11.18	3.04	22.17	$52 00
3270	College Farm, New Brunswick	12.27	1.19	17.95	45 00
3383	J. Y. Dilatush, Robbinsville	11.38	1.12	20.69	48 00
3503	Lamberson & Hance, Freehold	9.71	5.38	18 38	40 00
3508	Denise & Denise, Freehold	13.58	1.88	18.59	52 00
3527	J. H. Baird, Marlboro	13.63	0.55	17.08	47 00
	Average Cost per Pound	....	....	19.14	
	Dried and Ground Fish.				
3010	W. M. Perrine, Hightstown	8.70	6.32	16.06	33 00
3019	J. S. Collins & Son, Moorestown	8.52	6.96	17.56	35 00
3023	‡Hopkins & Lippincott, Moorestown	4.61	3.27	*22.10	23 00
3081	H. Clement, Woodbury	6.53	5.28	23.57	35 00
3127	W. J. Marl & Trans. Co., Sewell	8.15	6.15	18.45	35 00
3197	‡J. E Minch, Bridgeton	4.86	3.39	*26.02	28 00
3252	Fruit Growers' Union Cologne	7.83	5.20	18.56	33 22
3276	W G. Saalman Egg Harbor City	9.02	6.62	16.46	35 00
3384	J. Y. Dilatush, Robbinsville	9.15	7.62	13.06	30 00
3613	†J. W. Pincus, Woodbine	6.78	0.99	*23 02	32 00
3277	J. Hoenes, Cologne	6.82	5.99	22.15	35 00
3754	‡E. N. Strong, Ringoes	5.88	5.47	*14.47	21 40
	Average Cost per Pound			18.22	

* Not included in the average.

† King Crab.

‡ Crude Fish.

FORMS OF NITROGEN INSOLUBLE IN WATER.

TANKAGE.

Station Number.	FROM WHOM RECEIVED.	MECHANICAL ANALYSIS. Finer than 1/50 inch.	MECHANICAL ANALYSIS. Coarser than 1/50 inch.	PERCENTAGE. Nitrogen.	PERCENTAGE. Phosphoric Acid.	Cost of 2,000 lbs. of Material.
3003	W. M. Perrine, Hightstown	49	51	5.10	11.42	....
3022	Hopkins & Lippincott, Moorestown	50	50	5.03	11.68	$24 00
3129	L. M. Shock, Swedesboro	41	59	4.73	14.36	25 00
3271	College Farm, New Brunswick	72	28	5.94	16.51	26 00
3274	W. Wilde, Vineland	40	60	5.21	6.55	24 00
3275	W. G. Saalman, Egg Harbor City	68	32	4.20	15.76	27 00
3300	J. Hoenes, Cologne	67	33	5.38	11.17	29 00
3387	The Taylor Provision Co., Trenton	58	42	6.20	14.60	28 00
3388	Denise & Denise, Freehold	65	35	8.40	10.65	26 00
3389	" " "	61	39	4.75	17.90	21 00
3390	J. Y. Dilatush, Robbinsville	60	40	5.83	12.12	25 00
3504	Lamberson & Hance, Freehold	56	44	8.08	8.64	32 50
3509	Denise & Denise, Freehold	81	19	5.56	19.20	26 00
3510	" " "	67	33	6.66	14.36	26 00
3590	Ira Hill, Copper Hill	52	48	6.01	15.12	23 00
3591	" " " "	62	38	4.28	18.58	23 00

TANKAGE.

Station Number.		COST OF NITROGEN PER LB. IN— Finer than 1/50 inch.	COST OF NITROGEN PER LB. IN— Coarser than 1/50 inch.	COST OF PHOSPHORIC ACID PER LB. IN— Finer than 1/50 inch.	COST OF PHOSPHORIC ACID PER LB. IN— Coarser than 1/50 inch.
		cts.	cts.	cts.	cts.
3003	Tankage	....	....	....	....
3022	"	17.55	12.75	4.25	3.18
3129	"	18.05	13.11	4.37	3.28
3271	"	14.12	10.26	3.42	2.57
3274	"	*21.06	*15.30	*5.10	*3.83
3275	"	18.42	13.38	4.46	3.34
3300	"	*19.66	*14.28	*4.76	*3.57
3387	"	16.19	11.76	3.92	2.94
3388	"	13.21	9.60	3.20	2.40
3389	"	12.89	9.36	3.12	2.34
3390	"	15.98	11.61	3.87	2.90
3504	"	18.13	13.17	4.39	3.29
3509	"	13.42	9.75	3.25	2.44
3510	"	14.04	10.20	3.40	2.55
3590	"	13.63	9.90	3.30	2.48
3591	"	14.54	10.56	3.52	2.64
	Average Cost per Pound	**15.40**	**11.19**	**3.73**	**2.80**

* Not included in the average.

PLAIN SUPERPHOSPHATES.

Furnishing Soluble, Reverted and Insoluble Phosphoric Acid.

Station Number.	FROM WHOM RECEIVED.	PHOSPHORIC ACID. Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Available.	Cost of Available Phosphoric Acid per lb.	Cost of 2,000 lbs. of Material.
		%	%	%	%	cts	
3011	W. M. Perrine, Hightstown	13.62	1.74	1.61	15.36	3.58	$11 00
3058	H. W. Van Artsdalen, Titusville	11.80	2.34	1.83	14.14	*5 66	16 00
3272	College Farm, New Brunswick	10.08	3.40	4.20	13.48	4.45	12 00
3217	Mixner & Mickel, Bridgeton	12.92	1.74	1.76	14.66	4.09	12 00
3338	J. B. Warwick, Moorestown	9.96	3.83	1.83	13.79	3.26	9 00
3385	J. Y. Dilatush, Robbinsville	12.52	3.48	1.54	16.00	3.66	11 70
3507	Lamberson & Hance, Freehold	10.38	3.93	1.73	14.31	3.84	11 00
3614	J. W. Pincus, Woodbine	13.26	2.49	2.38	15.75	2.97	9 35
3750	C. G. MacMurray, Westfield	15.04	1.71	1.19	16.75	3.43	11 50
3478	J. Nodocker & Bro., Jamesburg	10.40	2.57	2.70	12.97	*6.55	17 00
3561	J. A. Shafer, Milford	10.70	3.84	3.10	14.54	4.81	14 00
3755	E. N. Strong, Ringoes	12.14	3.26	0.98	15.40	3 31	10 20
	Average Cost per Pound					3.74	

* Not included in the average.

GERMAN POTASH SALTS.

Station Number.	FROM WHOM RECEIVED.	Percentage of Potash.	Cost of Potash per lb.	Cost of 2,000 lbs. of Material.
	Muriate of Potash.	%	cts.	
3004	F. A. Updike, Hightstown	51.87	......	......
3020	J. S. Collins & Son, Moorestown	46.65	4.72	$44 00
3196	J. E. Minch, Bridgeton	51.10	4.40	45 00
3273	College Farm, New Brunswick	48.57	4.22	41 00
3506	Lamberson & Hance, Freehold	49.24	4.06	40 00
3615	J. W. Pincus, Woodbine	51.89	3.76	39 00
3756	E. N. Strong, Ringoes	52.06	3.88	40 40
	Average Cost per Pound	......	4.18	
	High-Grade Sulphate of Potash.			
3021	J. S. Collins & Son, Moorestown	50.38	4.96	50 00
	Kainit.			
3153	Hires & Co., Quinton	15.39	3.90	12 00
3192	V. D. Perrine, Monmouth Junction	12.46	*5.62	14 00
3193	" " " "	13.02	*5.76	15 00
3194	W. Harris, Bridgeton	13.07	4.59	12 00
	Average Cost per Pound	......	4.25	

* Not included in the average.

Home Mixtures and Special Compounds

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
HOME MIXTURES.		
B. R. Black, Mullica Hill	Mullica Hill	3152
Wm. Cox, Cranbury	Cranbury	3476
Hopkins and Lippincott, Moorestown	Moorestown	3024
L. E. Savacool, Newton (Potatoes)	Newton	3757
" " " (Corn)	"	3758
J. B. Warwick, Moorestown, (Potatoes)	Moorestown	3337
***SPECIAL COMPOUNDS.**		
American Agricultural Chemical Co., New York City.		
Grand View Grange Mixture No. 1	Flemington	3592
Baugh and Sons Co., Philadelphia, Pa.		
Gloucester County Grange White Potato Fertilizer	Mickleton	3672
" " " Sweet Potato Fertilizer	"	3673
E. Frank Coe Co., New York City.		
Lozier's No. 1 Truck Manure	Ridgewood	3617
" Gilt Edge Potato Manure	"	3618
Nassau Fertilizer Co., New York City.		
Pomona Grange Potato Mixture	Phillipsburg	3250
" " Grain Mixture	"	3251
Cortelyou's Grass Mixture	Neshanic	3583
Pomona Grange Mixture No. 1	Phillipsburg	3763
Plow Brand	"	3764
Hageman's Special Mixture	Readington	3765
Taylor Provision Co., Trenton, N. J.		
Ivins' Special Mixture	Trenton	3748
F. W. Tunnell and Co., Philadelphia, Pa.		
Ringoes Grange Mixture No. 1	Ringoes	3752
" " " No. 2	"	3753
" " " No. 2 for Pot. and Veg	"	3593
Grange Mixture No. 3	Readington	3766
Williams and Clark Branch, New York City.		
Millstone Grange Mixture No. 3	Millstone	3340
" " Peach Tree Special	"	3342

* See also page 75.

Home Mixtures and Special Compounds

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
1.45	......	1.96	3.41	......	4.20	4.58	1.77	10.55	....	8.78	....	*6.38	....	$26 00	$28 00
3.36	......	0.82	4.18	......	4.60	1.08	0.87	6.55	....	5.68	....	4.70	....	22 33	22 00
0.96	1.33	0.81	3.10	3.28	4.08	1.83	4.35	10.26	....	5.91	8.00	6.34	7.00	22 74	28 00
1.49	......	2.38	3.87	3.98	6.60	1.27	0.41	8.28	....	7.87	8.40	11.57	11.25	29 64	33 00
1.51	......	2.17	3.68	3.98	0.22	4.11	1.37	5.70	....	4.33	4.85	2.70	2.00	18 66	23 00
1.18	1.06	1.24	3.48	......	3.92	5.07	2.44	11.43	....	8.99	....	10.94	....	29 84	24 23
......	0.95	1.04	1.99	1.64	5.08	3.65	2.25	10.98	9.00	8.73	8.00	10.07	10.00	24 19	22 37
0.62	1.06	1.85	3.53	3.28	4.26	5.89	1.42	11.57	10.00	10.15	7.00	9.04	8.75	29 24	27 28
......	......	1.91	1.91	1.64	5.90	3.99	1.95	11.84	11.00	9.89	8.00	10.09	10.00	24 75	23 83
......	1.36	1.88	3.24	3.28	6.50	1.83	2.67	11.00	11.00	8.33	9.00	*5.68	4.00	25 40	26 00
......	0.55	1.47	2.02	1.64	5.54	1.51	2.43	9.48	9.50	7.05	8.00	*10.68	10.00	24 93	24 00
0.38	......	1.74	2.12	2.46	6.54	1.85	1.43	9.82	....	8.39	7.50	*8.65	8.00	23 84	24 45
......	0.99	0.69	1.68	1.64	6.24	2.26	2.82	11.32	....	8.50	8.00	4.04	4.00	18 03	17 90
5.95	......	0.54	6.49	6.40	6.36	2.06	1.27	9.69	....	8.42	8.40	....	....	27 77	28 00
0.30	.....	1.71	2.01	2.05	6.94	1.92	1.60	10.46	9.00	8.86	8.00	5.94	2.00	20 38	20 85
......	......	1.50	1.50	1.64	7.12	1.81	1.75	10.68	9.00	8.93	8.00	1.97	2.00	15 52	16 60
......	......	1.13	1.13	......	6.32	2.30	4.74	13.36	....	8.62	....	9.72	....	21 76	16 21
1.19	......	1.37	2.56	3.09	6.12	2.99	1.76	10.87	9.00	9.11	....	10.63	10.00	26 17	30 00
......	......	0.63	0.63	0.21	3.04	7.15	2.27	12.46	10.00	10.19	5.00	5.44	2.00	16 85	16 00
......	......	0.73	0.73	1.64	3.64	7.30	2.68	13.62	10.00	10.94	8.00	2.20	4.00	15 27	24 00
......	......	1.20	1.20	1.64	3.62	6.62	2.53	12.77	9.00	10.24	8.00	4.46	4.00	18 10	25 00
......	......	1.42	1.42	1.64	1.86	5.35	2.12	9.33	9.00	7.21	8.00	4.44	4.00	15 94	22 00
......	0.55	1.18	1.73	1.64	5.80	3.23	1.76	10.79	9.00	9.03	8.00	*9.63	10.00	24 40	25 25
......	......	......	......	.....	8.40	2.34	1.39	12.13	11.00	10.74	10.00	7.98	8.00	17 01	18 25

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
J. H. Allen and Son, Lawrence Station, N. J.		
Potato and Truck Manure	Lawrence Station	3391
Complete Phosphate	" "	3392
American Agricultural Chemical Co., New York City.		
Bradley Branch.		
New Method Fertilizer	Keyport	3364
Complete Manure for Potatoes and Vegetables	Freehold	3511
Potato Fertilizer	Belvidere	3709
Grass and Lawn Top Dressing	Baptistown	3554
Niagara Phosphate	Afton	3710
Potato Manure	Newton	3726
Chemical Co. of Canton Branch.		
Special Compound	Cologne	3256
Baker's Standard High-Grade Guano	"	3279
Truckers' Delight	"	3280
Chicopee Branch.		
Farmers' Reliable	Lyons Farms	3657
Vegetable and Potato Manure	Westwood	3682
Special New Jersey Brand	Lyons Farms	3659
Standard Guano	Westwood	3683
Clark's Cove Branch.		
Fish and Potash	Keyport	3367
Great Planet Manure	Plainsboro	3401
Unicorn Fertilizer	Englishtown	3402
Crocker Branch.		
Cabbage and Potato Manure	Adelphia	3515
Wheat and Corn Fertilizer	Paterson	3712
Special Potato Manure	Adelphia	3517
East India Branch.		
"A A" Ammoniated Superphosphate	Red Bank	3315
Turnip Manure	Keyport	3368
Potato Manure	"	3370
Complete Manure for General Use	West Long Branch	3318
Vegetable, Vine and Potato Manure	Ewingville	3408
Harvest Home Phosphate	Morristown	3729
Standard UNXLD Fertilizer	Plainsboro	3411
Great Eastern Branch.		
General	Blackwood	3109
Vegetable, Vine and Tobacco Fertilizer	Toms River	3320

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available.		Found.	Guaranteed.		
										Found.	Guaranteed.				
......	0.93	2.31	3.24	3.28	5.56	2.00	1.34	8.90	10.00	7.56	7.00	8.58	10.00	$25 74	$33 00
0.70	......	1.75	2.45	2.46	4.98	4.02	3.43	12.43	11.00	9.00	9.00	2.32	2.00	19 49	25 00
......	......	1.27	1.27	0.82	6.62	1.68	2.21	10.51	9.00	8.30	8.00	2.49	2.00	14 78	21 00
0.34	0.71	2.13	3.18	3.28	5.68	2.31	2.66	10.65	9.00	7.99	8.00	7.30	7.00	25 21	30 00
0.45	......	1.63	2.08	2.05	6.84	1.97	1.71	10.52	9.00	8.81	8.00	3.27	3.00	18 28	24 00
0.64	0.47	2.68	3.79	3.90	3.48	1.75	3.49	8.72	6.00	5.23	5.00	*2.60	2.00	21 39	29 00
......	......	1.11	1.11	0.82	2.80	3.97	2.73	9.50	8.00	6.77	7.00	1.56	1.00	12 28	20 00
......	1.07	1.48	2.55	2.46	4.92	1.92	1.98	8.82	7.00	6.84	6.00	6.64	6.00	21 37	30 00
0.41	......	1.55	1.96	2.05	4.04	3.74	2.80	10.58	9.00	7.78	8.00	6.11	6.00	19 82	29 50
0.67	......	1.28	1.95	2.05	4.40	3.77	1.69	9.86	9.00	8.17	8.00	3.43	3.00	17 30	26 00
......	0.21	2.08	2.29	2.46	3.94	3.78	2.11	9.83	9.00	7.72	8.00	4.53	4.00	19 45	28 00
......	.....	0.94	0.94	0.82	4.68	2.12	2.39	9.19	8.00	6.80	7.00	1.50	1.00	11 56	20 25
0.70	0.33	1.66	2.69	2.46	5.68	3.11	2.76	11.55	9.00	8.79	8.00	6.30	6.00	23 27	30 00
......	0.22	2.04	2.26	2.46	5.38	1.90	1.84	9.12	7.00	7.28	6.00	10.15	10.00	23 63	31 50
......	......	0.96	0.96	0.82	6.88	1.36	2.53	10.77	9.00	8.24	8.00	4.54	4.00	15 55	24 00
......	......	1.95	1.95	1.64	5.86	1.89	2.50	10.25	9.00	7.75	8.00	2.41	2.00	16 66	25 00
0.68	......	2.73	3.41	3.28	4.84	2.74	1.48	9.06	9.00	7.58	8.00	6.76	7.00	24 48	32 00
......	......	1.66	1.66	1.64	6.42	1.80	2.53	10.75	9.00	8.22	8.00	2.61	2.00	16 27	22 00
......	0.22	2.47	2.69	2.46	5.76	2.49	1.75	10.00	9.00	8.25	8.00	5.97	6.00	22 38	29 00
......	0.20	1.75	1.95	2.05	6.92	1.95	1.69	10.56	9.00	8.87	8.00	1.99	1.50	17 00	25 00
0.33	0.49	2.22	3.04	3.28	7.00	0.99	1.37	9.36	9.00	7.99	8.00	8.30	7.00	25 06	31 00
0.66	......	1.84	2.50	2.46	6.58	2.86	1.70	11.14	11.00	9.44	9.00	2.61	2.00	19 64	30 50
0.57	1.77	3.59	5.93	5.74	4.18	1.21	0.99	6.38	6.00	5.39	5.00	*7.84	9.00	33 21	41 00
0.51	0.81	1.90	3.22	3.28	3.40	3.88	1.40	8.68	7.00	7.28	6.00	10.50	10.00	26 87	34 00
0.63	......	1.71	2.34	2.46	6.32	2.47	1.79	10.58	9.00	8.79	8.00	5.89	6.00	21 34	31 00
......	1.82	1.49	3.31	2.46	5.10	2.05	1.60	8.75	7.00	7.15	6.00	10.62	10.00	27 55	32 00
......	0.51	0.96	1.47	1.03	7.06	2.16	1.66	10.88	9.00	9.22	8.00	2.78	2.00	16 37	25 00
......	0.87	1.26	2.13	2.05	7.80	1.64	1.53	10.97	9.00	9.44	8.00	*3.68	3.00	19 88	26 00
......	......	0.88	0.88	0.82	3.58	4.70	2.19	10.47	9.00	8.28	8.00	4.21	4.00	14 90	20 00
......	0.43	1.48	1.86	2.05	5.20	3.08	1.67	9.95	9.00	8.28	8.00	3.21	3.00	17 22	26 00

* Potash largely, if not entirely in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
American Agricultural Chem. Co., N. Y. City.—(Cont.)		
Great Eastern Branch.—(Cont.)		
Garden Special	Blackwood	3111
Northern Corn Special	Princeton	3413
Wheat Special	Somerville	3628
English Wheat Grower	"	3629
Milsom Branch.		
Buffalo Guano	Paterson	3717
Potato, Hop and Tobacco Fertilizer	"	3718
Blood, Bone and Potash Fertilizer	Newton	3735
Packers' Uuion Branch.		
Potato Manure	Grenloch	3115
Gardeners' Complete Manure	Gloucester	3141
Universal Fertilizer	Erma	3228
Animal Corn Fertilizer	Hopewell	3440
Pacific Guano Branch.		
Special Potato Manure	Martinville	3441
Ammoniated Dissolved Bone	Millington	3442
Nobsque Guano	Hightstown	3493
Potato Phosphate	Millington	3444
A No 1 Phosphate	"	3445
Soluble Guano	Hightstown	3495
Moro Phillips Branch.		
Fish Guano	Medford	3096
Cumberland Special for Potatoes	Vineland	3229
No. 1 Potato and Truck Manure	"	3230
Farmers' Phosphate	"	3231
Preston Branch.		
Potato and Onion Fertilizer	Fishing Creek	3248
Corn Guano	Burlington	3042
Ten Per Cent. Potato Fertilizer	Egg Harbor City	3287
Potato Fertilizer	Freehold	3446
Pioneer Fertilizer	Verona	3663
Quinnipiac Branch.		
Market Garden Manure	Quinton	3167
Special Potato Manure	Washington	3719
Read Branch.		
Potato Manure	Vineland	3233
Standard Superphosphate for Corn, Wheat and Rye	Three Bridges	3607

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
1.44	......	1.64	3.08	3.28	6.68	1.65	1.12	9.45	9.00	8.33	8.00	7.13	7.00	$23 91	$35 00
0.40	.....	1.79	2.19	2.46	7.70	1.47	1.64	10.81	11.00	9.17	9.00	2.06	2.00	17 94	25 00
......	......	1.72	1.72	1.64	3.42	4.80	3.20	11.42	9.00	8.22	8.00	1.87	2.00	16 12	22 00
......	......	0.85	0.85	0.82	2.76	4.96	3.26	10.98	9.00	7.72	8.00	1.87	2.00	12 73	20 00
......	......	0.91	0.91	0.82	6.94	2.07	2.32	11.33	9.00	9.01	8.00	4.10	4.00	15 62	25 00
......	0.24	1.77	2.01	2.05	6.56	2.36	2.48	11.40	9.00	8.92	8.00	3.25	3.00	18 64	28 00
0.75	.....	2.39	3.14	3.28	3.16	3.55	2.75	9.46	7.00	6.71	6.00	10.88	10.00	26 77	30 00
......	0.58	1.41	1.99	2.05	6.06	2.21	2.48	10.75	9.00	8.27	8.00	5.72	6.00	20 11	27 00
0.74	0.82	1.51	3.07	3.28	4.36	2.53	2.38	9.27	7.00	6.89	6.00	9.18	10.00	25 17	32 00
......	......	0.90	0.90	0.82	3.46	3.92	3.05	10.43	9.00	7.38	8.00	3.88	4.00	14 22	23 00
0.32	......	2.11	2.43	2.46	7.48	1.58	1.94	11.00	11.00	9.06	9.00	2.95	2.00	19 57	25 00
......	1.05	1.50	2.55	2.46	4.80	2.27	1.86	8.93	7.00	7.07	6.00	7.34	6.00	22 12	26 60
......	......	1.56	1.56	1.64	7.36	2.58	2.87	12.81	9.00	9.94	8.00	2.25	2.00	17 31	22 00
......	......	1.08	1.08	1.03	7.20	1.46	1.45	10.11	9.00	8.66	8.00	2.25	2.00	13 95	20 00
......	......	0.47	0.47	1.23	4.80	2.44	2.78	10.02	7.00	7.24	6.00	5.94	5.00	14 28	22 00
......	......	0.99	0.99	0.82	2.38	4.32	3.03	9.73	8.00	6.70	7.00	1.45	1.00	11 84	18 00
......	......	1.92	1.92	2.05	6.96	1.84	2.00	10.80	9.00	8.80	8.00	2.08	1.50	17 02	28 00
0.71	......	1.07	1.78	1.85	2.18	2.96	1.78	6.92	6.00	5.14	5.00	1.21	1.00	12 12	20 00
0.28	......	1.23	1.51	1.23	6.72	2.04	1.97	10.73	9.00	8.76	8.00	10.06	10.00	22 24	28 00
0.71	......	1.09	1.80	2.05	6.00	2.79	1.98	10.77	9.00	8.79	8.00	6.00	6.00	19 64	27 00
......	......	0.87	0.87	0.82	1.20	6.29	2.49	9.98	8.00	7.49	7.00	1.22	1.00	11 74	18 00
0.56	......	1.75	2.31	2.46	2.46	3.49	2.23	8.18	7.00	5.95	6.00	6.19	6.00	19 13	29 00
0.40	......	1.26	1.66	1.64	4.24	3.94	2.18	10.36	9.00	8.18	8.00	3.21	3.00	16 44	24 00
0.37	.....	1.22	1.59	1.64	5.86	2.76	2.42	11.04	9.00	8.62	8.00	9.62	10.00	22 17	34 00
0.58	0.38	1.80	2.76	3.28	7.80	1.71	1.49	11.00	9.00	9.51	8.00	5.91	7.00	23 37	30 00
......	......	1.29	1.29	1.03	2.94	4.59	3.05	10.58	9.00	7.53	8.00	2.08	2.00	14 16	25 00
0.72	0.70	1.06	2.48	3.28	6.86	1.21	1.31	9.38	9.00	8.07	8.00	6.38	7.00	21 41	29 00
......	......	1.32	1.32	1.23	4.16	2.29	3.16	9.61	7.00	6.45	6.00	5.84	5.00	16 52	26 00
0.66	......	1.50	2.16	2.46	2.58	3.84	1.60	8.02	7.00	6.42	6.00	10.35	10.00	22 30	30 00
......	......	0.75	0.75	0.82	5.62	2.63	1.77	10.02	9.00	8.25	8.00	4.16	4.00	14 23	21 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
American Agricultural Chem. Co., N. Y. City.—(Cont.)		
Read Branch.—(Cont.)		
Truck Fertilizer	Vineland	3234
Bone, Fish and Potash	Pomona	3288
Farmers' Friend Superphosphate	Blairstown	3739
Leader Blood and Bone	Englishtown	3449
High-Grade Farmers' Friend	Chester	3736
Practical Potato Special	Hope	3737
Vegetable and Vine Fertilizer	Blairstown	3740
Sharpless and Carpenter Branch.		
Soluble Tampico Guano	Medford	3097
Gilt Edge Potato and Tobacco Manure	Vineland	3235
Fish Guano	Medford	3099
No. 1 Bone Phosphate	Cedarville	3305
Susquehanna Branch.		
Potato Phosphate	Hope	3745
Tygert-Allen Branch.		
Nitro-Phosphate	Mt. Holly	3080
Marine Guano	Matawan	3382
Special Brand Potato Manure	Woodbury	3104
Seven Per Cent. Guano	Collingswood	3118
Star Guano	Bridgeton	3238
Popular Phosphate	Pleasantville	3292
Star Bone Phosphate	Jackson's Mills	3330
Potato Manure	" "	3331
Wheeler Branch.		
Potato Manure,	Sewell	3122
Special Vegetable Manure	"	3119
Corn Fertilizer	"	3120
Sweet Potato Manure	Toms River	3336
Williams and Clark Branch.		
Americus Fertilizer	Dayton	3472
High-Grade Special Fertilizer	Adelphia	3524
Potato Phosphate	Rahway	3671
Potato, Corn and Truck Special	East Millstone	3360
Royal Bone Phosphate	Dayton	3470
Good Grower Potato Phosphate	"	3471
Americus Universal Ammon. Diss. Bone	Martinville	3473
Prolific Fertilizer	Annandale	3649

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.98	1.26	0.98	3.22	3.28	5.66	2.05	1.71	9.42	9.00	7.71	8.00	6.95	7.00	$24 21	$30 00
0.81	......	1.56	2.37	2.46	3.70	3.02	2.45	9.17	7.00	6.72	6.00	5.45	6.00	19 39	28 00
0.26	......	1.35	1.61	2.05	7.10	1.51	1.72	10.33	9.00	8.61	8.00	3.51	3.00	16 79	28 00
......	......	0.84	0.84	0.82	5.88	1.49	1.36	8.73	8.00	7.37	7.00	1.64	1.00	11 42	20 00
0.26	0.37	2.24	2.87	3.28	4.76	2.27	2.23	9.26	7.00	7.03	6.00	8.49	10.00	24 14	33 00
.....	......	0.81	0.81	0.82	2.98	1.27	2.29	6.54	5.00	4.25	4.00	9.30	8.00	15 41	26 00
0.50	......	1.57	2.07	2.05	6.36	1.25	1.44	9.05	9.00	7.61	8.00	6.76	6.00	20 02	30 00
0.81	0.96	1.31	3.08	3.28	6.36	2.22	1.34	9.92	9.00	8.58	8.00	6.57	7.00	24 09	30 00
0.41	......	1.21	1.62	1.64	4.66	3.62	2.72	11.00	9.00	8.28	8.00	10.49	10.00	22 80	28 00
0.37	0.25	1.41	2.03	2.05	5.08	2.86	3.00	10.94	9.00	7.91	8.00	6.16	6.00	20 37	27 00
0.50	......	1.12	1.62	1.64	3.72	4.18	2.47	10.37	9.00	7.90	8.00	2.30	2.00	15 37	23 00
......	......	1.53	1.53	1.64	5.18	3.14	1.33	9.65	9.00	8.32	8.00	4.93	5.00	17 41	26 00
0.72	......	1.38	2.10	2.05	4.18	3.98	1.92	10.08	9.00	8.16	8.00	3.37	3.00	17 83	25 00
......	1.70	1.48	3.18	3.28	5.58	2.67	2.87	11.12	9.00	8.25	8.00	7.66	7.00	26 07	35 00
......	0.56	1.24	1.80	2.05	6.28	2.26	2.28	10.82	9.00	8.54	8.00	5.88	6.00	19 78	28 00
1.17	1.23	2.12	4.52	5.74	4.48	1.71	1.73	7.92	7.00	6.19	6.00	6.16	5.00	26 53	38 00
......	......	1.97	1.97	2.05	4.58	3.19	2.10	9.87	9.00	7.77	8.00	3.49	3.00	17 50	25 00
......	......	0.86	0.86	0.82	4.86	3.09	1.86	9.81	9.00	7.95	8.00	2.24	2.00	12 72	20 00
0.82	......	1.13	1.95	2.05	3.30	4.56	2.31	10.17	9.00	7.86	8.00	3.07	3.00	16 90	25 75
0.76	0.82	1.59	3.17	3.28	3.34	4.03	1.88	9.25	7.00	7.37	6.00	9.63	10.00	26 13	33 00
0.38	......	1.66	2.04	2.05	5.06	3.10	1.92	10.08	9.00	8.16	8.00	3.08	3.00	17 51	25 00
0.42	......	1.32	1.74	1.64	4.14	3.81	1.82	9.77	9.00	7.95	8.00	10.15	10.00	22 27	28 00
0.41	......	1.21	1.62	1.64	3.94	4.69	2.14	10.77	9.00	8.63	8.00	2.68	2.00	16 22	23 00
0.78	......	1.16	1.94	2.05	5.44	3.46	2.00	10.90	9.00	8.90	8.00	5.69	6.00	19 93	28 00
......	......	2.63	2.63	2.46	6.36	2.92	3.09	12.37	11.00	9.28	9.00	2.33	2.00	20 51	27 00
......	1.07	2.05	3.12	3.28	5.00	3.56	3.01	11.57	9.00	8.56	8.00	7.91	7.00	26 34	31 00
......	0.21	2.25	2.46	2.46	4.18	2.93	3.15	10.26	7.00	7.11	6.00	6.54	6.00	21 61	32 00
......	0.20	1.90	2.10	1.64	6.36	2.71	3.45	12.52	9.00	9.07	8.00	3.48	3.00	19 66	22 00
......	......	1.26	1.26	1.03	4.28	3.67	3.10	11.05	9.00	7.95	8.00	2.43	2.00	14 85	21 00
......	......	1.26	1.26	0.82	5.98	2.11	2.66	10.75	9.00	8.09	8.00	5.09	4.00	16 95	23 00
......	......	1.70	1.70	1.64	6.70	2.00	2.29	10.99	9.00	8.70	8.00	2.47	2.00	16 63	23 00
.....	......	1.05	1.05	0.82	2.54	4.93	2.66	10.13	8.00	7.47	7.00	1.29	1.00	12 45	20 09

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Armour Fertilizer Works, Baltimore, Md.		
Grain Grower	Merchantville	3082
High-Grade Potato	Monmouth Junction	3394
Manure Substitute	Salem	3176
All Soluble	Monmouth Junction	3393
Ammoniated Bone with Potash	Bound Brook	3622
Wheat, Corn and Oats Special	" "	3623
Fruit and Root Crop Special	Hackensack	3675
Warren Atkinson, Mullica Hill, N. J.		
High-Grade Potato and Early Truck Manure	Mullica Hill	3130
Potato and General Truck Fertilizer	" "	3131
Special Sweet Potato Fertilizer	" "	3132
Special Early Tomato Grower	" "	3133
All Around Fertilizer	" "	3134
James H. Baird, Marlboro, N. J.		
Potato Mixture	Marlboro	3530
Asparagus Fertilizer	"	3531
Grass Mixture	"	3532
Five Per Cent. Potato	"	3533
Baugh and Sons Co., Philadelphia, Pa.		
Potato Fertilizer	Milford	3552
Special Potato Manure	Mt. Holly	3060
General Crop Grower	Lambertville	3551
The Berg Co., Philadelphia, Pa.		
$25 Special Bone Manure	Elmer	3178
H. G. Odorless Velvety Lawn Dressing	Belvidere	3702
$35 Potato Manure	Medford	3084
Lymph Guano for All Crops	"	3085
Standard Bone Manure	Hammonton	3254
Pure Dissolved Bone and Potash	Stockton	3553
Special Potato Guano	Belvidere	3700
Berger Bros., Easton, Pa.		
Peerless Phosphate	Phillipsburg	3703
Potato and Truck	"	3704
Bowker Fertilizer Co., Boston, Mass.		
Sweet Potato and Truck Manure	Cologne	3255
Early Potato Manure	Swedesboro	3156
Potash-Bone	East Millstone	3344
Potato and Vegetable Fertilizer	Bridgeton	3199

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.		
0.49	.....	1.17	1.66	1.64	5.84	3.06	1.22	10.12	10.00	8.90	8.00	2.11	2.00	$15 75	$21 00
0.47	......	1.19	1.66	1.64	6.34	2.79	0.89	10.02	10.00	9.13	8.00	*10.16	10.00	22 93	30 00
1.00	.....	2.24	3.24	3.28	4.81	2.10	1.12	8.06	....	6.94	6.00	4.21	4.00	20 90	29 00
1.35	......	1.20	2.55	2.87	7.24	2.09	0.65	9.98	10.00	9.33	8.00	*4.99	4.00	21 78	30 00
0.39	......	1.89	2.28	2.46	3.36	3.18	2.14	8.68	8.00	6.54	6.00	2.43	2.00	16 41	24 00
......	......	0.81	0.81	0.82	4.72	2.72	1.39	8.83	9.00	7.44	7.00	1.04	1.00	10 89	19 00
0.41	......	1.54	1.95	1.64	6.90	1.91	0.93	9.74	10.00	8.81	8.00	4.93	5.00	19 06	30 00
0.66	1.08	1.78	3.52	3.69	7.50	3.23	1.17	11.90	11.00	10.73	8.00	7.23	7.00	28 09	32 00
0.57	......	1.97	2.54	2.46	6.46	3.41	1.28	11.15	10.00	9.87	7.00	7.49	7.00	24 17	28 00
......	......	1.65	1.65	1.64	4.60	3.91	1.73	10.24	10.00	8.51	8.00	11.86	10.00	24 04	28 00
1.59	0.25	2.86	4.70	4.92	6.20	2.95	0.92	10.07	9.00	9.15	8.00	4.96	5.00	28 20	33 00
......	......	2.11	2.11	2.05	6.14	1.60	0.61	8.35	8.00	7.74	6.00	4.5[illegible]	4.00	18 21	23 00
1.65	1.00	0.90	3.55	3.28	4.38	3.22	2.63	10.23	8.00	7.60	7.00	9.69	10.00	27 64	30 00
3.30	....	2.39	5.69	5.74	2.08	4.[illegible]4	1.63	8.45	7.00	6.82	5.00	2.92	2.50	27 30	32 50
6.76	.....	1.37	8.13	8.20	1.52	3.23	1.00	5.75	....	4.75	4.00	5.50	5.00	34 30	37 00
1.14	1.29	1.59	3.93	4.10	5.20	2.68	1.93	9.81	....	7.88	7.00	9.[illegible]5	10.00	28 83	31 00
......	......	1.86	1.86	1.64	4.74	3.82	3.44	12.00	....	8.56	8.00	2.26	2.00	17 32	23 00
......	.....	1.65	1.65	1.64	3.16	3.41	2.07	8.64	....	6.57	5.00	10.54	10.00	21 31	28 00
......	.....	0.97	0.97	0.82	5.58	3.40	2.26	11.24	....	8.98	8.00	1.38	1.00	13 45	20 00
......	......	2.10	2.10	1.64	3.[illegible]8	5.87	2.97	12.22	....	9.25	7.00	3.14	2.00	19 33	22 00
1.43	......	2.27	3.70	4.92	1.92	8.36	4.61	14.89	17.00	10.28	....	6.99	5.00	29 04	45 00
0.56	......	1.81	2.37	2.46	5.12	2.36	3.29	10.77	....	7.48	7.00	10.08	10.00	24 44	30 00
0.51	.....	2.84	3.35	2.87	4.20	3.96	4.29	12.45	10.00	8.16	7.00	5.55	8.00	24 97	35 00
0.24	.....	2.01	2.25	2.46	4.76	3.79	4.53	13.08	....	8.55	8.00	4.89	6.00	21 22	30 00
......	......	2.10	2.10	2.46	4.20	4.83	4.42	13.45	....	9.03	9.00	4.20	3.50	20 61	26 00
1.10	......	2.24	3.34	3.28	4.12	3.87	3.46	11.45	9.00	7.99	7.00	10.1[illegible]	8.00	28 11	40 00
.....	......	0.79	0.79	0.82	3.46	2.17	2.89	8.52	10.00	5.63	8.00	2.08	2.00	10 69	21 00
1.10	......	1.34	2.44	2.46	5.42	2.89	2.45	10.76	9.00	8.31	8.00	5.86	6.00	21 30	32 00
0.70	......	1.22	1.92	1.64	2.98	3.82	1.93	8.73	7.00	6.80	6.00	8.19	8.00	20 10	30 00
0.84	......	2.60	3.44	3.28	3.02	4.05	1.87	8.94	8.00	7.07	7.00	7.58	7.00	24 91	28 00
......	......	0.96	0.96	0.82	5.00	2.09	1.41	8.50	7.00	7.09	6.00	2.15	2.00	12 03	20 00
0.51	0.29	1.39	2.19	2.46	6.40	2.21	3.10	11.71	10.00	8.61	8.00	3.71	4.00	19 42	30 00

* Potash largely, if not entirely, in form of sulphate.

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Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Bowker Fertilizer Co., Boston, Mass.—(Cont.)		
Farm and Garden Phosphate	Blackwood	3136
Market Garden Fertilizer	East Millstone	3346
Sure Crop Phosphate	Shiloh	3219
Potato and Vegetable Phosphate	Paterson	3707
Lawn and Garden Dressing, Double Strength	Plainfield	3652
Corn Phosphate	Califon	3639
Bone and Potash, Square Brand	Clinton	3650
Fish and Potash, Square Brand	Plainfield	3653
Ammoniated Dissolved Bone	Montclair	3655
Bone and Wood Ash Fertilizer	Newton	3725
Stockbridge Potato and Vegetable	River Edge	3676
" Corn Manure	Chatham	3706
" Top Dressing	Paterson	3705
Bradley and Green Fertilizer Co., Philadelphia, Pa.		
Seven Per Cent. Ammonia Guano	Matawan	3362
Extra High-Grade Potato Guano	Freehold	3396
Wm. M. Brown, Cedarville, N. J.		
Special Potato Manure	Cedarville	3202
E. Frank Coe Co., New York City.		
Extra Special Potato Fertilizer	Freehold	3514
New Englander Potato Fertilizer	Hackettstown	3728
High-Grade Potato	Closter	3679
Alkaline Bone Phosphate	Bound Brook	3624
Original Ammon. Dissolved Bone Phosphate	Hightstown	3481
Red Brand Excelsior Guano	Freehold	3512
O. H Dilts' Animal Bone Manure	Ringoes	3594
XXV. Ammoniated Bone Phosphate	New Market	3627
Excelsior Guano	Elizabeth	3656
Famous American Lawn Fertilizer	Closter	3678
J. S. Collins and Son, Moorestown, N. J.		
Cabbage and Tomato Fertilizer	Moorestown	3025
Fish Guano	"	3026
Truck Guano	"	3027
H. G. Fertilizer for Potatoes and General Use	"	3028
Collins and Pancoast, Merchantville, N. J.		
H. G. Fertilizer for Potatoes and General Use	Merchantville	3029
Cabbage and Tomato Fertilizer	"	3086

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.28	.....	1.29	1.57	1.64	5.12	3.08	2.03	10.23	9.00	8.20	8.00	2.24	2.00	$15 32	$25 00
0.71	......	1.64	2.35	2.46	4.04	2.71	3.42	10.17	7.00	6.75	6.00	9.73	10.00	23 42	32 00
......	......	0.93	0.93	0.82	5.54	3.51	2.86	11.91	11.00	9.05	9.00	2.06	2.00	14 20	22 00
0.30	......	1.21	1.51	1.64	5.72	3.57	2.59	11.88	10.00	9.29	9.00	2.28	2.00	16 35	28 00
3.32	......	0.54	3.86	3.28	4.16	1.13	0.84	6.13	8.00	5.29	4.00	4.82	5.00	21 00	33 00
......	0.50	1.39	1.89	1.64	5.84	1.95	1.77	9.56	9.00	7.79	8.00	2.25	2.00	16 10	25 00
......	......	1.39	1.39	1.64	4.36	3.01	3.88	11.25	10.00	7.37	6.00	2.08	2.00	14 68	27 00
......	0.26	2.08	2.34	2.46	2.64	2.24	2.89	7.77	8.00	4.88	....	4.10	4.00	17 02	33 00
0.16	0.26	1.17	1.59	1.64	6.02	3.03	2.35	11.40	9.00	9.05	8.00	2.27	2.00	16 39	35 00
0.69	......	1.08	1.77	1.64	....	3.10	7.09	10.19	8.00	3.10	6.00	2.29	2.00	13 32	25 00
0.84	......	2.48	3.32	3.28	3.60	2.53	3.32	9.45	7.00	6.13	6.00	9.15	10.00	25 58	36 00
0.99	0.60	1.78	3.37	3.28	5.20	2.81	2.07	10.08	8.00	8.01	7.00	7.37	7.00	25 43	36 00
1.72	0.83	1.73	4.28	4.92	5.86	1.26	0.82	7.94	6.00	7.12	4.00	6.01	6.00	25 80	40 00
0.83	0.52	4.19	5.54	5.74	6.32	1.22	0.81	8.35	9.00	7.54	7.00	5.38	5.00	30 24	38 00
......	0.56	2.70	3.26	3.28	4.28	2.46	1.73	8.47	8.00	6.74	6.00	10.39	10.00	26 73	30 00
0.80	......	1.89	2.69	2.46	4.60	3.80	2.00	10.40	....	8.40	7.00	6.91	10.00	23 06	28 00
......	0.53	1.12	1.65	1.64	6.84	1.18	2.58	10.60	9.50	8.02	8.00	*9.37	10.00	23 10	29 00
......	......	1.08	1.08	0.82	7.48	1.50	2.72	11.70	9.00	8.98	7.50	*3.69	3.00	16 53	26 00
......	1.00	1.66	2.66	2.46	6.12	1.41	3.04	10.57	9.00	7.53	7.50	*6.14	6.00	23 28	36 00
......	0.35	1.25	1.60	1.23	6.98	1.92	4.40	13 30	10.00	8.90	8.50	*3.85	2.50	19 10	25 50
......	......	1.77	1.77	1.23	7.24	1.51	3.15	11.90	....	8.75	9.00	*2.45	2.25	17 61	25 00
......	1.50	1.41	2.91	3.28	7.42	1.44	2.74	11.60	10.00	8.86	9.00	*6.19	6.00	25 30	34 00
......	......	0.99	0.99	1.03	7.20	0.92	4.82	12.94	8.00	8.12	7.00	*1.92	1.50	14 53	22 00
......	......	1.14	1.14	0.82	7.80	1.36	2.71	11.87	10.00	9.16	8.50	1.93	1.50	14 84	24 00
......	1.35	1.94	3.29	3.28	6.92	1.57	2.69	11.18	10.50	8.49	9.00	*3.82	3.40	23 86	40 00
......	1.00	1.87	2.87	3.28	6.48	1.02	3.12	10.62	7.00	7.50	6.00	*6.21	4.00	24 07	40 00
0.63	......	2.55	3.18	3.28	5.48	3.03	1.12	9.63	....	8.51	7.00	5.55	5.00	23 39	27 00
0.84	......	1.59	2.43	2.46	3.34	5.53	2.55	11.42	....	8.87	8.00	4.34	4.00	20 62	26 00
0.31	......	1.31	1.62	1.64	4.24	3.95	1.93	10.12	....	8.19	8.00	2.30	2.00	15 48	23 00
0.73	......	1.73	2.46	2.46	6.36	2.90	1.03	10.29	....	9.26	8.00	*10.16	10.00	25 78	28 00
0.64	......	1.67	2.31	2.46	6.04	3.50	1.02	10.56	....	9.54	8.00	*10.91	10.00	26 39	28 00
1.44	......	1.79	3.23	3.28	4.28	4.26	1.67	10.21	....	8.54	7.00	5.35	5.00	23 32	27 00

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND	WHERE SAMPLED.	Station Number.
A. A. Cortelyou, Neshanic, N. J.		
Special Fertilizer	Neshanic	3587
I. S. Curtis, Frenchtown, N. J.		
High-Grade Bone Phosphate	Frenchtown	3555
S. V. Davis, Shiloh, N. J.		
May Queen Fertilizer	Shiloh	3222
B. F. Demarris and Son, Cedarville, N. J.		
Complete No. 1 Bone Phosphate	Roadstown Road	3221
Fish Guano for Sweet Potatoes	Cedarville	3303
Truckers' Potato Manure	"	3304
Denise and Denise, Freehold, N. J.		
Fruit and Vine Fertilizer	Freehold	3539
Special Potato Fertilizer	West Freehold	3405
Complete Manure	Cranbury	3484
Peruvian Guano	Freehold	3519
Truck Fertilizer	"	3534
Corn Special	"	3535
High-Grade Fertilizer	"	3536
Grass Fertilizer	"	3538
H. R. Disbrow and Co., Allentown, N. J.		
Complete G. and G. Fertilizer	Martinville	3406
Early Potato Guano	"	3407
H. W. Doughten, Moorestown, N. J.		
Special Potato Manure	Moorestown	3087
Sure Shot Superphosphate	"	3088
Dried Ground Fish Guano	"	3089
Eagle Guano Co., New York City.		
Manure for Early Crops	Ridgewood	3684
Frank Emmons, Newton, N. J.		
Special Potato Manure	Newton	3730
J. C. Fifield and Sons Co., Bakersville, N. J.		
Special Potato and Cabbage Manure	Woodbury	3090
Special Sweet Potato Manure	Cologne	3257
Mixture	Woodbury	3092
Fish and Potash	Cologne	3281
Fithian and Pennell, Bridgeton, N. J.		
Complete Phosphate	Bridgeton	3203
James C. Griscom, Woodbury, N. J.		
King Crab Compound	Woodbury	3112

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	0.24	1.40	1.64	2.46	1.44	4.58	2.34	8.36	12.00	6.02	....	5.70	4.00	$16 81	$25 00
......	......	1.64	1.64	1.64	4.06	4.37	3.15	11.58	....	8.43	8.00	2.58	6.00	16 62	26 00
......	0.21	1.37	1.58	1.64	6.24	3.19	1.58	11.01	10.00	9.43	8.00	2.43	2.00	16 58	24 00
......	......	1.72	1.72	1.64	5.60	3.22	2.68	11.50	11.00	8.82	9.00	1.91	2.00	16 48	24 00
......	......	2.31	2.31	2.46	5.48	2.71	1.65	9.84	9.50	8.19	7.50	2.42	2.00	17 94	25 00
0.71	......	1.52	2.23	2.46	6.88	2.52	1.83	11.23	11.00	9.40	9.00	4.74	6.00	20 52	30 00
2.17	0.20	1.81	4.18	4.51	4.46	5.56	2.74	12.76	....	10.02	9.00	4.81	5.00	27 57	30 00
1.51	......	1.67	3.18	3.49	3.70	4.62	2.43	10.75	....	8.32	8.00	10.55	10.00	27 64	30 00
1.39	......	1.71	3.10	3.28	5.74	3.95	1.87	11.56	10.00	9.69	....	10.20	10.00	28 12	32 00
0.32	1.09	0.41	1.82	1.64	0.48	7.42	24.82	32.72	32.00	7.90	....	0.79	1.00	23 88	25 50
2.78	......	2.14	4.92	4.92	4.12	4.51	2.20	10.83	....	8.63	8.00	5.94	5.00	29 32	30 00
1.01	......	1.49	2.50	2.46	6.04	5.08	2.39	13.51	....	11.12	12.00	5.17	5.00	23 47	26 00
1.92	......	1.83	3.75	4.10	4.78	3.78	2.23	10.79	....	8.56	8.00	9.21	8.00	28 40	30 00
5.70	......	2.10	7.80	7.38	2.54	4.10	0.86	7.50	....	6.64	6.00	5.57	5.00	35 31	36 00
......	0.82	1.79	2.61	2.46	6.62	2.73	1.81	11.16	10.00	9.35	8.00	4.77	4.00	22 16	25 00
......	0.90	3.25	4.15	4.10	4.54	3.49	1.81	9.84	....	8.03	7.00	*6.03	5.00	27 69	34 00
......	1.27	1.07	2.34	2.46	8.74	1.26	0.68	10.68	....	10.00	10.00	6.92	7.00	23 24	29 00
......	0.90	1.56	2.46	2.46	7.50	2.26	1.67	11.43	10.00	9.76	9.00	3.38	3.00	20 77	27 00
......	0.20	3.18	3.38	3.69	4.40	1.69	1.63	7.72	5.85	6.09	....	3.28	3.00	20 43	28 00
0.76	......	1.50	2.26	2.46	7.08	1.24	0.75	9.07	9.00	8.32	8.00	3.25	3.00	17 93	32 00
1.19	......	2.19	3.38	3.28	6.08	2.97	1.53	10.58	....	9.05	7.00	9.51	9.00	27 96	31 50
......	......	2.38	2.38	2.46	3.16	5.18	2.05	10.39	....	8.34	7.00	7.36	7.00	22 68	35 00
......	......	2.18	2.18	2.05	0.94	6.10	1.61	8.65	....	7.04	5.00	9.67	10.00	22 61	35 00
......	0.54	1.48	2.02	2.46	0.54	5.48	1.87	7.89	....	6.02	5.00	3.17	3.00	15 79	28 00
......	......	2.09	2.09	1.64	2.50	4.89	1.19	8.58	....	7.39	7.00	5.37	4.00	18 81	30 00
......	0.20	1.27	1.47	1.64	6.68	2.99	1.46	11.13	10.00	9.67	8.00	2.31	2.00	16 26	23 50
0.57	0.53	1.85	2.95	4.10	7.38	2.02	1.14	10.54	10.00	9.40	8.00	5.41	5.00	23 38	32 00

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
William Harris, Bridgeton, N. J.		
Complete Phosphate	Bridgeton	3204
Wyckoff Hendrickson, Allentown, N. J.		
Corn and Truck Manure	Cranbury	3485
Special Potato Manure	Allentown	3418
High-Grade Potato Manure	Newtown	3417
Raw Bone and Potash	Robbinsville	3419
Wheat and Rye	"	3420
Special Grain Manure	"	3421
S. M. Hess & Bro., Philadelphia, Pa.		
Special Potato Manure	Marlboro	3540
Fish and Potash Manure	"	3542
Keystone Bone Phosphate	"	3543
Special Compound	Ringoes	3597
Jacob Higgins, Flemington, N. J.		
Golden Rod	Flemington	3588
Ira Hill, Copper Hill, N. J.		
Potato Fertilizer	Copper Hill	3599
Pure Bone Phosphate	" "	3600
Hill & Co., Flemington, N. J.		
Corn Manure	Flemington	3575
Standard Fertilizer	"	3576
No. 2	"	3577
Hires & Co., Quinton, N. J.		
Special High-Grade Potato Manure	Quinton	3157
Potato and Tomato Grower	"	3158
W. B. Hitchner, Woodstown, N. J.		
High-Grade Potato Manure	Woodstown	3159
P. Hoffman & Bro., Raullsville, Pa.		
Potato Fertilizer	Phillipsburg	3713
International Seed Co., Rochester, N. Y.		
Potato and Truck Manure	Cologne	3259
Grain and Grass Fertilizer	Ridgewood	3685
Hervey Kuhl, Flemington, N. J.		
Ammoniated Dissolved Bone	Flemington	3578
Lackawanna Fertilizer and Chemical Co., Moosic, Pa.		
Moosic Phosphate	Stillwater	3731

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
From Nitrates.	From Ammonia Salts.	From Organic Matter.	**Total Found.**	**Total Guaranteed.**	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	**Total Found.**	**Total Guaranteed.**	**Available. Found.**	**Available. Guaranteed.**	**Found.**	**Guaranteed.**	**Value of 2,000 lbs. at Station's Prices.**	**Selling Price of 2,000 lbs. at Consumers' Depot.**
0.46	......	1.12	1.58	2.05	5.00	3.37	1.56	9.93	11.00	8.37	9.00	5.62	2.50	$18 12	$24 00
0.33	......	1.45	1.78	1.64	5.68	3.64	3.64	12.96	11.00	9.32	9.00	5.48	4.00	20 43	25 20
0.70	......	1.83	2.53	2.46	5.36	2.90	2.24	10.50	10.00	8.26	8.00	9.64	10.00	24 84	30 00
0.68	......	2.50	3.18	3.28	7.00	1.92	1.09	10.01	....	8.92	9.00	10.19	10.00	27 67	32 00
......	......	2.83	2.83	2.46	....	9.37	7.93	17.30	16.00	9.37	....	11.38	12.50	30 89	30 00
......	......	0.40	0.40	0.82	8.04	2.73	3.43	14.20	....	10.77	9.00	1.14	1.00	13 39	18 00
0.61	......	1.65	2.26	1.64	7.12	2.99	2.77	12.88	11.00	10.11	9.00	4.18	3.00	21 20	25 00
......	0.61	2.58	3.19	3.28	7.00	1.52	1.81	10.33	....	8.52	8.00	7.50	7.00	25 68	32 00
......	......	1.80	1.80	2.05	7.14	1.47	1.72	10.33	....	8.61	8.00	3.17	3.00	17 26	26 00
......	......	0.88	0.88	0.82	6.08	1.69	1.99	9.76	10.00	7.77	8.00	1.80	1.00	12 31	22 00
......	......	0.97	0.97	0.82	3.14	4.79	2.84	10.77	9.00	7.93	8.00	3.86	4.00	14 86	23 00
......	......	1.14	1.14	1.23	5.60	2.06	2.42	10.08	....	7.66	8.00	5.40	4.00	16 33	20 00
......	......	2.38	2.38	2.46	1.80	6.26	2.16	10.22	....	8.06	10.50	9.73	9.00	24 47	28 00
......	......	2.10	2.10	2.05	1.76	6.61	1.72	10.09	....	8.37	10.50	3.40	2.50	18 25	23 00
......	......	1.50	1.50	1.64	7.52	1.55	1.48	10.55	....	9.07	8.00	2.76	3.00	16 20	22 00
......	......	2.14	2.14	1.64	5.28	4.73	1.47	11.48	9.00	10.01	8.00	3.54	3.00	19 89	22 00
......	......	1.36	1.36	0.82	5.44	3.23	3.53	12.20	9.00	8.67	8.00	2.41	2.00	15 88	18 00
1.05	......	0.50	1.55	2.46	1.32	5.19	2.75	9.26	....	6.51	7.00	6.10	10.00	17 00	29 00
0.90	......	0.94	1.84	2.46	2.46	4.25	3.25	9.96	....	6.71	8.00	4.45	5.00	17 02	24 00
......	......	2.14	2.14	2.46	4.10	2.93	1.95	8.98	....	7.03	7.00	7.80	8.00	21 02	25 00
1.33	......	1 71	3.04	0.82	0.64	4.03	5.17	9.84	9.00	4.67	7.00	7.40	4.00	22 36	32 00
0.22	......	1.16	1.38	1.23	4.64	3.38	2.07	10.09	9.00	8.02	8.00	7.02	7.00	18 62	28 00
.....	......	1.65	1.65	1.64	7.52	2.34	3.37	13.23	11.00	9.86	10.00	2.52	2.00	17 97	25 00
0.40	......	1.16	1.56	1.64	4.64	3.95	2.74	11.33	10.00	8.59	8.00	2.02	2.00	15 69	23 00
......	......	1.05	1.05	1.23	5.16	3.36	2.31	10.83	9.00	8.52	7.00	2.16	1.50	14 00	22 00

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Lamberson and Hance, Freehold, N. J.		
Potato and Truck Fertilizer	Freehold	3544
High-Grade Potato Fertilizer	"	3545
4-8-10 Fertilizer	"	3546
Samuel Lederer and Sons, New Brunswick, N. J.		
Potato Fertilizer	New Brunswick	3660
Lister's Agricultural Chemical Works, Newark, N. J.		
U S. Superphosphate	Skillman	3427
Special Ten Per Cent. Potato	Middlebush	3350
Corn and Potato Fertilizer	"	3352
Special Corn Fertilizer	Lebanon	3644
Pure Bone Superphosphate of Lime	Keyport	3371
Potato Manure	Freehold	3423
Mt. Rose Corn Fertilizer	Pennington	3425
"G" Brand	Skillman	3426
Special Crop Producer	Ringoes	3601
Ammoniated Dissolved Bone Phosphate	"	3606
Success Fertilizer	Lebanon	3642
Potato Fertilizer, No. 2	"	3643
Corn Fertilizer, No. 2	Passaic	3686
Lawn Fertilizer	"	3687
3-6-10 for Potatoes	Madison	3715
Mapes Formula and Peruvian Guano Co., N. Y. City.		
Complete Manure "A" Brand	Skillman	3431
Fruit and Vine Manure	Camden	3030
Cauliflower and Cabbage Manure	"	3031
Potato Manure	Eatontown	3322
Vegetable Manure, or Complete for Light Soils	Matawan	3376
Complete Manure for Average Soils	Hammonton	3262
Economical Potato Manure	"	3263
Corn Manure	River Vale	3588
Complete Manure for Heavy Soils	Matawan	3378
General Crop Brand	Flemington	3579
Grass and Grain Spring Top Dressing	Montclair	3662
Complete Manure for General Use	Rivervale	3689
Cereal Brand	Chester	3732
Complete Manure, Ten Per Cent. Potash	"	3733

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Available. Found.	Available. Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
1.38	......	2.06	3.44	3.49	4.20	3.80	2.92	10.92	....	8.00	8.00	7.40	7.50	$25 80	$29 00
1.98	......	2.26	4.24	4.10	3.90	4.20	1.32	9.42	....	8.10	8.00	7.83	8.00	28 10	30 00
1.89	......	1.62	3.51	3.28	4.56	3.92	1.23	9.71	....	8.48	8.00	10.25	10.00	28 01	30 00
0.59	0.40	1.24	2.23	3.28	2.32	4.70	2.84	9.86	10.00	7.02	....	5.16	7.00	19 24	30 00
......	......	1.46	1.46	1.03	7.28	2.94	2.35	12.57	10.00	10.22	8.00	*2.34	2.00	17 44	20 00
......	0.26	1.39	1.65	1.64	7.06	1.01	1.13	9.20	....	8.07	8.00	*11.46	10.00	24 81	30 00
......	0.27	1.39	1.66	1.64	6.00	2.82	2.63	11.45	9.00	8.82	8.00	3.37	3.00	17 54	25 00
......	0.43	1.28	1.71	1.64	5.86	3.16	2.67	11.69	9.00	9.02	8.00	3.47	3.00	18 00	25 00
......	0.58	1.82	2.40	2.46	6.94	2.36	3.42	12.72	11.00	9.30	9.00	2.47	2.00	20 06	25 00
......	1.16	2.04	3.20	3.28	7.40	1.43	2.12	10.95	9.00	8.83	8.00	7.86	7.00	26 48	32 00
......	......	1.50	1 50	1.64	8.12	1.27	2.79	12.18	10.00	9.39	8.00	*1.80	1.50	16 47	23 00
......	......	1.05	1.05	0.82	5.28	3.72	2.79	11.79	10.00	9.00	8.00	2.56	4.00	14 97	21 00
......	......	1.03	1.03	0.82	6.20	2.02	3.02	11.24	8.00	8.22	7.00	*1.19	1.00	13 30	18 00
......	0.73	1.29	2.02	2.05	6.16	3.20	3.15	12.51	9.00	9.36	8.00	*1.92	1.50	18 55	23 00
......	......	1.29	1.29	1.23	7.52	2.11	2.31	11.94	11.00	9.63	9.00	*2.29	2.00	16 27	23 00
......	0.52	1.29	1.81	1.64	9.28	1.62	2.29	13.19	11.00	10.90	10.00	*4.25	4.00	21 19	28 00
......	0.79	1.04	1.83	1.64	7.04	2.24	1.60	10.88	11.00	9.28	10.00	*4.63	4.00	19 93	28 00
......	1.67	0.37	2.04	1.64	4.72	3.60	0.91	9.23	9.00	8.32	8.00	*3.33	3.00	18 29	27 00
......	0.30	1.41	1.71	2.46	7.12	0.94	1.69	9.75	....	8.06	6.00	*11.16	10.00	24 93	33 00
0.94	......	1.82	2.76	2.46	2.26	9.25	3.08	14.59	12.00	11.51	10.00	2.97	2.50	23 13	31 00
1.23	0.24	0.52	1.99	1.64	1.80	3.58	3.23	8.61	7.00	5.38	5.00	*11.71	10.00	24 14	37 50
2.92	......	1.20	4.12	4.10	1.68	5.69	2.25	9.62	6.00	7.37	6.00	6.97	6.00	23 30	37 50
2.70	0.44	1.13	4.27	3.69	3.68	4.48	2.07	10.23	8.00	8.16	8.00	*6.96	6.00	28 61	39 00
3.72	......	2.01	5.73	4.92	2.88	3.65	2.31	8.84	8.00	6.53	6.00	*7.45	6.00	32 24	40 00
2.77	......	1.14	3.91	4.10	3.28	3.93	1.43	8.64	8.00	7.21	7.00	*5.68	5.00	24 93	37 00
1.82	......	1.38	3.20	3.28	2.10	3.43	2.36	7.89	6.00	5.53	4.00	*8.23	8.00	24 30	37 00
0.95	......	1.49	2.44	2.46	3.36	5.37	2.34	11.07	10.00	8.73	8.00	6.86	6.00	22 55	35 00
3.01	0.27	1.84	5.12	4.92	2.54	4.28	3.95	10.77	10.00	6.82	8.00	*3.86	3.00	27 82	39 00
0.39	......	1.20	1.59	1.64	4.00	4.59	2.46	11.05	10.00	8.59	8.00	2.52	2.00	16 10	25 00
2.86	0.43	1.20	4.49	4.92	2.84	4.22	3.00	10.06	6 00	7.06	5.00	7.44	7.00	28 04	42 00
2.17	0.33	0.99	3.49	3.28	1.68	5.60	3.80	11.08	10.00	7.28	8.00	4.14	4.00	22 63	37 00
0.56	......	1.[illegible]3	1.89	1.64	3.04	4.40	2.50	9.94	8.00	7.44	6.00	2.98	3.00	16 43	28 00
1.01	......	1.45	2.46	2.05	1.76	3.85	1.13	6.74	5.00	5.61	3.00	9.75	10.00	21 75	32 00

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
The D. B. Martin Co., Philadelphia, Pa.		
Corn and Oats Special	Sewell	3113
Gilt Edge Potato and Tomato Fertilizer	Freehold	3429
Dissolved Organic Compound	Lambertville	3556
Lawn Dressing and Food for Plants	Somerville	3631
John E. Minch, Bridgeton, N. J.		
Complete Phosphate	Bridgeton	3205
Sweet Potato Manure	"	3206
Mitchell Fertilizer Co., Tremley, N. J.		
Vegetable Fertilizer	Matawan	3379
Mixner and Mickel, Bridgeton, N. J.		
High-Grade Manure	Bridgeton	3225
Top Dresser for Strawberries, Asparagus and Onions	"	3226
Fish Mixture	"	3227
Monmouth Chemical Works, Shrewsbury, N. J.		
Special Truck Fertilizer	Shrewsbury	3324
Special Potato Fertilizer	"	3326
J. R. Moore, Swedesboro, N. J.		
Early Tomato Manure	Swedesboro	3160
Sweet Potato Manure	"	3161
Nassau Fertilizer Co., New York City.		
Peerless Potato Phosphate	Monmouth Junction	3432
General Favorite	Neshanic	3582
National Fertilizer Co., Bridgeport, Conn.		
Chittenden's Fish and Potash	Red Bank	3327
Albert Nelson and Co., Allentown, N. J.		
"A" Brand, Special Potato Manure	Allentown	3488
High-Grade Superphosphate	Windsor	3489
Special A Potato Manure	"	3490
Special Potato Manure	"	3491
New Jersey Agricultural Chemical Co., Newark, N. J.		
Russell's Special Corn Manure	Hopewell	3437
Newport Fertilizer Co., Philadelphia, Pa.		
No. 1 Bone Phosphate	Moorestown	3035
Hilton Brand	"	3038
Truckers' Joy	Camden	3039
Gilt Edge Potato and Tobacco Manure	Swedesboro	3140
Rectified Phosphate	Matawan	3381
Wheat and Grass Special	Montana	3768

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
.....	......	1.44	1.44	1.64	3.46	2.99	6.99	13.44	16.00	6.45	8.00	1.89	2.00	$15 12	$22 00
0.84	......	1.05	1.89	1.64	4.40	3.38	3.96	11.74	13.00	7.78	7.00	9.32	10.00	22 59	32 00
.....	......	1.14	1.14	1.03	3.62	2.58	6 95	13.15	17.00	6.20	9.00	1.95	2.00	13 90	20 00
0.69	......	1.45	2.14	2.05	2.80	7.15	5.84	15.79	18.00	9.95	....	3.52	3.00	21 29	40 00
1.00	......	0.81	1.81	2.05	4.00	3.60	3.08	10.68	....	7.60	9.00	4.23	4.00	17 42	24 00
......	......	1.04	1.04	1.64	3.18	3.69	3.18	10.05	....	6.87	9.00	10.22	10.00	19 68	30 00
0.67	......	3.14	3.81	3.28	6.26	3.45	1.57	11.28	10.00	9.71	9.00	6.01	6.00	27 17	38 00
0.95	......	1.36	2.31	2.46	1.74	4.67	1.70	8.11	....	6.41	6.00	10.16	10.00	22 56	30 00
2.65	......	1.50	4.15	4.51	4.86	2.34	0.94	8.14	....	7.20	6.00	10.09	10.00	28 48	34 00
......	......	2.48	2.48	2.46	3.72	3.02	1.53	8.27	....	6.74	6.00	3.63	3.50	18 20	25 00
......	......	2.97	2.97	3.28	0.72	4.54	1.29	6.55	6.75	5.26	6.00	3.87	4.00	18 64	28 00
......	......	1.80	1.80	2.46	2.04	3.92	1.08	7.04	8.00	5.96	6.66	7.87	8.00	18 60	28 00
1.31	1.41	3.30	6.02	5.74	4.98	1.91	0.92	7.81	7.00	6.89	6.00	5.54	5.00	31 37	35 00
......	0.58	1.33	1.91	1.64	6 38	1.51	2.56	10.45	9.00	7.89	8.00	*8.66	10.00	23 33	28 00
......	......	1.69	1.69	1.64	6.92	1.63	1.51	10.06	....	8.55	8.00	10.53	10.00	23 00	27 00
......	......	1.05	1.05	0.82	7.56	1.10	1.94	10.60	9.00	8.66	8.00	3.98	4.00	15 82	20 00
......	......	3.03	3.03	2.87	4.38	2.25	2.40	9.03	....	6.63	6.00	*4.26	4.00	21 49	30 00
1.19	......	1.00	2.19	2.05	5.84	3.17	2.00	11.01	9.00	9.01	8.00	10.13	10.00	24 49	30 00
0.71	......	1.15	1.86	1.64	7.02	3.36	2.84	13.22	10.00	10.38	8.00	2.91	3.00	18 99	25 00
1.17	......	1.59	2.76	2.46	5.48	3.03	2.40	10.91	9.00	8.51	8.00	10.93	12.00	26 83	32 00
1.05	......	0.84	1.89	1.64	6 32	2.88	2.24	11.44	....	9.20	8.00	10.17	10.00	23 84	28 00
......	......	1.50	1.50	1.64	2.04	4.64	8.18	14.86	9.00	6.68	8.00	1.95	3.00	16 04	24 00
0.52	......	1.31	1.83	1.64	5.10	5.15	2.15	12.40	9.00	10.25	8.00	3.51	2.00	19 08	25 00
1.97	......	1.49	3.46	3.28	4.80	5.02	1.69	11.51	....	9.82	7.00	9.06	10.00	28 20	29 00
1.65	......	1.56	3.21	4.10	3.94	5.64	2.19	11.77	9.00	9.58	8.00	7.79	6.00	26 37	31 00
......	......	1.38	1.38	1.64	3.78	3.24	2.51	9.53	9.00	7.02	8.00	11.46	10.00	21 75	28 00
2.19	......	0.89	3.08	3.28	3.66	3.29	1.92	8.87	8.00	6.95	7.00	5.35	5.00	21 18	32 00
......	......	0.44	0.44	0.41	1.96	6.43	2.26	10.65	....	8.39	8.00	2.22	2.00	11 84	20 00

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Newport Fertilizer Co., Philadelphia, Pa.—(Cont.)		
Evans Brand	Camden	3041
Potato, Tobacco and Truck Guano	Bergen Fields	3690
Fish, Bone and Potash	Columbus	3094
Improved Tampico Guano	Cold Spring	3244
Top Notch Brand	Pennington	3434
Special Compound	Lambertville	3558
Farmers' Ammoniated Bone Phosphate	Potterstown	3647
James E. Otis, Tuckerton, N. J.		
Menhaden Fish Guano	Cologne	3264
Special for Potatoes	Jackson's Mills	3328
S. L. Pancoast, Mullica Hill, N. J.		
Early Truck Fertilizer	Mullica Hill	3144
Early Potato Grower	" "	3145
Peterson and Smith, Woodstown, N. J.		
Potato Superphosphate	Woodstown	3163
Wheat and Oats Superphosphate	"	3164
Half-and-Half	"	3165
High-Grade Potato Fertilizer	"	3166
R. H. Pollock, Baltimore, Md.		
Owl Brand Guano	Milford	3560
Accomac Trucker	Egg Harbor City	3283
Special Potato and Tobacco Fertilizer	" " "	3284
Quaker City Poudrette Co., Philadelphia, Pa.		
Quaker City Poudrette	Mount Holly	3061
John Repp, Glassboro, N. J.		
High-Grade White Potato Fertilizer	Glassboro	3146
High-Grade Fertilizer	"	3147
Enos Richmond, Elmer, N. J.		
Special Oat and Wheat Fertilizer	Hainesburg	3741
Special Potato Phosphate	"	3742
Special Corn Manure	"	3743
Edward Rigg, Jr., Burlington, N. J.		
Potato Manure	Burlington	3043
Fish Guano	"	3044
M. F. Riley, Elmer, N. J.		
High-Grade Potato	Elmer	3179
Grain Manure	"	3180
Special Potato Manure	"	3181

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
3.29	......	1.02	4.31	3.28	3.50	5.98	1.72	11.20	8.00	9.48	7.00	6.37	10.00	$27 98	$32 00
......	......	0.66	0.66	0.82	1.18	4.11	2.88	8.17	7.00	5.29	6.00	5.64	6.00	12 94	24 00
0.71	......	0.52	1.23	1.64	2.52	3.11	4.06	9.69	8.00	5.63	7.00	4.83	5.00	14 70	26 00
0.75	......	0.48	1.23	1.64	2.36	3.62	4.11	10.09	....	5.98	7.00	4.59	5.00	14 80	25 00
......	......	0.85	0.85	0.63	6.88	2.76	3.51	13.15	....	9.64	11.00	1.57	0.25	14 31	21 00
......	.....	0.81	0.81	1.03	3.22	4.80	4.04	12.06	11.00	8.02	10.00	1.69	2.00	13 03	20 00
......	......	0.61	0.61	0.82	2.32	5.63	3.10	11.05	....	7.95	8.00	4.18	4.00	14 02	25 00
......	......	2.97	2.97	3.28	4.00	3.49	1.67	9.16	7.00	7.49	....	5.87	5.00	22 50	26 75
......	0.29	2.21	2.50	1.64	3.24	4.44	1.83	9.51	8.00	7.68	....	8.90	10.00	23 74	29 00
0.31	.....	1.90	2.24	2.67	6.50	2.74	2.30	11.54	....	9.24	8.00	5.70	5.00	21 57	25 00
0.68	.....	2.25	2.93	3.28	6.08	2.29	1.66	10.03	....	8.37	7.00	8.09	7.50	24 76	27 00
0.66	......	1.64	2.30	2.46	7.12	1.83	0.96	9.91	8.00	8.95	6.00	9.78	10.00	24 31	27 00
......	......	1.25	1.25	0.82	2.18	4.65	1.39	8.22	10.00	6.83	8.00	2.59	2.00	13 16	17 00
......	.....	1.82	1.82	1.64	2.32	5.07	4.61	12.00	....	7.39	9.00	3.94	3.00	18 03	21 00
......	0.93	1.99	2.92	3.28	7.00	1.83	1.19	10.02	10.00	8.83	8.00	7.33	8.00	24 69	29 00
......	......	0.42	0.42	0.41	1.14	4.91	2.65	8.70	8.00	6.05	7.00	2.35	1.50	9 94	18 50
......	1.30	2.34	3.64	4.10	3.70	3.67	3.29	10.66	10.00	7.37	7.00	5.26	5.00	24 93	35 00
.....	......	1.33	1.33	1.64	4.76	2.55	2.38	9.69	9.00	7.31	8.00	3.80	4.00	15 28	27 00
......	......	1.08	1.08	1.64	0.52	2.66	0.35	3.53	4.00	3.18	....	0.49	1.00	7 09	16 60
......	......	2.18	2.18	2.87	8.06	0.98	0.38	9.42	10.00	9.04	8.00	9.32	10.00	23 62	30 00
......	......	1.72	1.72	2.05	6.78	2.30	0.69	9.77	10.00	9.08	8.00	9.33	10.00	22 23	27 00
......	......	0.77	0.77	0.82	7.20	0.79	2.05	10.04	....	7.99	8.00	2.55	2.00	12 80	17 50
......	......	1.56	1.56	1.64	6.60	1.63	1.56	9.79	9.00	8.23	8.00	8.96	10.00	20 95	27 50
......	......	0.99	0.99	0.82	6.84	2.06	2.01	10.91	....	8.90	9.00	3.50	3.00	15 16	19 50
0.36	......	1.44	1.80	1.64	4.72	3.44	1.22	9.38	....	8.16	8.00	9.75	10.00	22 10	28 00
......	......	2.58	2.58	2.46	4.64	2.80	2.13	9.57	....	7.44	7.00	5.03	6.00	20 60	27 00
0.30	......	2.36	2.66	2.46	2.00	5.25	2.53	9.78	....	7.25	7.00	*7.43	8.00	23 17	26 00
0.49	......	1.03	1.52	1.64	3.56	3.89	2.96	10.41	....	7.45	8.00	3.20	3.00	15 58	23 00
1.02	......	0.56	1.58	1.64	1.96	6.33	3.16	11.45	....	8.29	8.00	5.59	5.00	18 43	25 00

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Ruckman Bros., New Brunswick, N. J.		
Truck Fertilizer	New Brunswick	3666
Potato Fertilizer	" "	3667
Corn and Grain Fertilizer	" "	3668
Scott Fertilizer Co., Elkton, Md.		
Higgins' Grain Special	Flemington	3585
Sure Growth Superphosphate	Frenchtown	3609
Sharpless and Bro., Camden, N. J.		
Seven Per Cent. Truck Guano	Camden	3045
Ten Per Cent. Truck Guano	"	3046
Extra High-Grade Potato Manure	"	3047
No. 1 for General Use	"	3048
Special Potato Manure	"	3049
J. E. Sherman, Frenchtown, N. J.		
Potato Manure	Frenchtown	3564
Corn Manure	"	3565
M. L. Shoemaker and Co., Philadelphia, Pa.		
Swift-Sure Superphosphate for General Use	Westville	3117
" " " Potatoes	Rio Grande	3246
" Special Ten Per Cent. Potato Fertilizer, No. 1	Medford	3101
" " " " " " " No. 2	Hopewell	3451
" Guano for Tomatoes, Truck and Corn	Woodstown	3169
New Jersey Special for Wheat and Corn	Collingswood	3116
Good Enough Superphosphate	Monmouth Junction	3450
Echo Superphosphate	Newton	3744
L. W. Sickler, Glassboro, N. J.		
Special Ten Per Cent. Potato Fertilizer	Glassboro	3148
Guano for Tomatoes, Truck and Corn	"	3149
Joseph Smith and Co., Stockton, N. J.		
Special Potato Fertilizer	Stockton	3566
Special Fertilizer	"	3567
Standard Fertilizer	"	3568
Prallsville Formula for Corn and Potatoes	"	3569
Oats Fertilizer	"	3570
Rufus W. Smith, Elmer, N. J.		
Complete Bone Fertilizer	Elmer	3182
High-Grade Trucker Fertilizer	"	3184
Ammoniated Consummate Fertilizer	"	3185

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.					Available.		Potash.			
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
1.07	0.92	2.28	4.27	4.00	1.38	5.25	4.59	11.22	9.00	6.63	6.00	4.26	4.00	$25 61	$30 00
......	0.80	2.27	3.07	2.50	2.24	5.55	3.72	11.51	9.00	7.79	6.00	8.10	8.00	25 91	33 00
......	1.07	2.63	3.70	2.50	1.34	5.97	4.78	12.09	9.00	7.31	6.00	4.27	4.00	24 81	27 00
......	......	0.42	0.42	0.41	10.38	1.62	0.46	12.46	....	12.00	10.00	3.62	4.00	15 49	20 00
......	......	1.55	1.55	1.64	7.64	2.95	2.78	13.37	12.00	10.59	10.00	2.41	2.50	17 96	24 00
2.64	......	1.52	4.16	5.74	3.76	1.61	2.07	7.44	....	5.37	5.00	8.22	9.00	25 74	38 00
1.49	1.73	3.03	6.25	8.20	2.70	2.71	1.50	6.91	....	5.41	4.00	5.54	4.00	31 01	44 00
1.33	......	1.83	3.16	3.28	4.56	3.59	1.61	9.76	....	8.15	7.00	9.45	10.00	26 22	32 00
0.72	......	0.71	1.43	1.64	3.76	3.50	2.63	9.89	....	7.26	8.00	2.49	2.00	14 27	23 00
......	......	1.09	1.09	1.85	4.00	2.81	3.32	10.13	....	6.81	7.00	10.08	10.00	19 74	28 00
0.42	......	1.09	1.51	1.64	4.36	4.66	2.11	11.13	....	9.02	8.00	7.56	7.00	20 36	26 00
0.41	......	1.10	1.51	1.64	4.28	4.59	1.94	10.81	....	8.87	8.00	7.60	7.00	20 19	25 00
0.88	.....	1.66	2.54	2.87	6.90	3.66	4.34	14.90	14.00	10.56	9.00	4.99	4.50	23 76	31 00
0.96	......	1.71	2.67	2.87	7.04	3.20	3.81	14.05	11.00	10.24	8.00	7.45	7.00	25 76	32 00
1.31	......	2.11	3.42	3.28	5.78	1.68	1.74	9.20	....	7.43	6.00	11.15	10.00	27 99	28 00
0.68	......	1.15	1.83	1.64	5.84	2.82	4.09	12.75	....	8.66	8.00	10.61	10.00	24 40	30 00
0.33	......	1.50	1.83	1.64	5.16	3.73	4.21	13.10	....	8.89	8.00	5.50	5.00	20 45	25 00
......	......	1.31	1.31	1.03	2.68	5.64	4.47	12.79	....	8.32	8.00	2.26	2.00	15 65	20 00
0.39	......	1.20	1.59	1.64	9.20	2.51	1.62	13.33	12.00	11.71	8.00	2.66	2.00	18 70	25 00
......	......	1.28	1.28	1.23	6.14	2.23	1.96	10.33	9.00	8.37	7.00	2.54	1.50	14 82	24 00
0.60	......	1.10	1.70	2.05	5.66	3.77	3.20	12.63	....	9.43	8.00	10.62	10.00	24 34	35 00
0.60	......	1.33	1.93	1.64	5.74	3.62	3.31	12.67	....	9.36	8.00	5.24	5.00	20 51	28 00
0.76	......	1.76	2.52	2.46	3.90	3.27	1.80	8.97	7.00	7.17	6.00	10.68	10.00	24 50	29 00
......	......	0.97	0.97	0.82	5.08	2.51	2.93	10.52	9.00	7.59	8.00	2.22	2.00	13 19	18 50
......	......	0.96	0.96	0.82	5.32	3.29	2.51	11.12	9.00	8.61	8.00	4.31	4.00	15 68	20 00
......	0.83	1.34	2.17	2.05	4.72	2.50	2.32	9.54	9.00	7.22	8.00	6.78	6.00	20 66	25 50
......	......	1.08	1.08	0.82	1.40	5.54	2.44	9.38	8.00	6.94	7.00	1.39	1.00	12 08	17 00
......	.....	2.20	2.20	2.05	6.72	2.09	2.42	11.23	10.00	8.81	8.00	3.13	3.00	19 04	23 00
......	......	2.25	2 25	2.46	5.40	2.25	2.09	9.74	9.00	7.65	7.00	*8.04	8.00	23 11	27 50
......	......	0.96	0.96	0.82	6.20	2.68	1.45	10.33	10.00	8.88	9.00	2.73	3.00	14 15	18 50

* Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
Taylor Bros., Camden, N. J.		
Animal Bone Phosphate	Camden	3052
The Taylor Provision Co., Trenton, N. J.		
High-Grade Corn and Truck Manure	Cedarville	3309
Special Potato Fertilizer	Hammonton	3266
Top Dressing for Grass	"	3268
Bone, Tankage and Potash	East Millstone	3354
A. D. B. Special Fertilizer	Lambertville	3572
I. P. Thomas & Son Co., Philadelphia, Pa.		
High-Grade Potato Manure	Freehold	3522
Sweet Potato Manure	Moorestown	3053
Cabbage Manure	"	3054
Vegetable Manure	Titusville	3062
Improved Superphosphate	Monmouth Junction	3452
Grain Manure	Roselle	3669
Farmers' Choice Bone Phosphate	"	3670
Screenings	Bridgeton	3210
Special Potato Manure	Monmouth Junction	3455
Wheat and Grass Compound	Titusville	3072
Fish Guano	Freehold	3522
Trenton Bone and Fertilizer Co., Trenton, N. J.		
Excelsior	Elmer	3186
$32 Potato Manure	Robbinsville	3461
Potato Manure	Middlebush	3356
Special Corn Mixture	Hightstown	3499
Ammoniated Dissolved Bone	Pennington	3456
Grain Manure	Ringoes	3610
Bergen Special	Ewingville	3460
Bone and Potash	Robbinsville	3463
5-6-10 Fertilizer	Plainsboro	3464
Stults' Special for Wheat and Grass	Princeton Junction	3465
Corn and Truck Fertilizer	" "	3466
Special Potato Manure	Freehold	3523
F. W. Tunnell & Co., Philadelphia, Pa.		
Potato and Vegetable Manure	Salem	3173
Rectified Improved Superphosphate	Monmouth Junction	3454
Royal Wheat Grower	White House Station	3635
Sweet and White Potato Manure	Titusville	3074
Animal Matter and Potash	"	3076

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
......	......	1.72	1.72	1.64	5.68	2.44	2.94	11.06	11.15	8.12	8.00	1.37	1.00	$15 51	$21 00
0.34	......	1.93	2.27	2.46	3.92	4.84	3.16	11.92	8.00	8.76	....	4.84	5.00	20 83	28 00
0.63	......	1.38	2.01	2.05	4.50	4.14	3.44	12.08	8.00	8.64	....	9.67	10.00	23 96	30 00
6.34	......	1.37	7.71	8.20	1.62	3.26	1.36	6.24	6.00	4.88	....	6.21	5.00	33 89	45 00
......	......	0.87	0.87	0.82	3.58	3.01	4.98	11.57	8.00	6.59	....	2.48	2.50	12 99	20 00
0.43	......	0.71	1.14	1.23	5.02	4.19	3.27	12.48	8.00	9.21	....	5.19	5.00	17 71	24 50
0.94	......	1.21	2.15	2.46	6.24	2.10	0.84	9.18	10.00	8.34	8.00	11.02	10.00	24 15	30 00
......	......	1.73	1.73	1.64	6.22	1.77	1.16	9.15	9.00	7.99	7.00	9.86	10.00	21 91	28 00
0.67	......	2.59	3.26	3.28	5.78	1.60	1.62	9.00	9.00	7.38	7.00	5.71	5.00	22 96	28 00
......	......	1.85	1.85	1.64	6.14	2.26	2.79	11.19	....	8.40	8.00	3.55	4.00	17 99	28 00
......	......	0.95	0.95	0.82	8.42	2.35	1.35	12.12	12.00	10.77	10.00	1.69	1.00	14 90	22 00
......	....	0.78	0.78	0.82	4.60	2.18	1.08	7.86	8.00	6.78	7.00	1.79	1.00	10 70	19 50
0.76	......	0.73	1.49	1.64	8.64	2.02	1.18	11.84	10.50	10.66	9.50	2.39	2.00	16 85	25 00
......	......	0.51	0.51	0.41	8.30	2.31	0.91	11.52	....	10.61	10.00	1.77	0.50	13 15	17 00
0.66	......	0.93	1.59	1.64	4.84	2.73	1.19	8.76	8.00	7.57	7.00	9.86	10.00	20 81	29 00
0.18	......	0.75	0.93	0.82	8.20	2.40	1.71	12.31	11.00	10.60	10.00	1.78	1.00	14 82	25 50
0.18	......	1.25	1.43	1.64	7.26	2.85	1.73	11.84	10.50	10.11	9.50	2.80	2.00	16 96	26 00
......	......	0.83	0.83	0.82	2.88	5.61	2.35	10.84	....	8.49	8.00	2.55	2.00	13 57	20 00
0.80	......	1.54	2.34	2.46	4.82	3.21	1.66	9.69	....	8.03	8.00	10.49	10.00	24 45	31 00
0.37	......	1.09	1.46	1.64	3.84	4.00	2.64	10.48	....	7.84	8.00	7.29	7.00	19 14	26 00
0.24	......	1.31	1.55	1.64	2.84	4.39	3.67	10.90	....	7.23	8.00	3.91	3.00	16 47	23 00
0.22	......	1.33	1.55	1.64	3.26	6.76	2.82	12.84	....	10.02	8.00	3.71	3.00	18 48	26 00
0.21	......	1.40	1.61	1.64	2.66	4.79	3.60	11.05	....	7.45	8.00	3.67	3.00	16 66	23 00
1.29	......	1.74	3.03	3.28	3.64	4.71	2.79	11.14	....	8.35	9.00	*10.37	10.00	27 77	34 00
0.41	......	1.99	2.40	2.05	2.82	7.92	2.70	13.44	....	10.74	11.00	3.66	3.00	21 86	26 00
1.83	......	1.76	3.59	4.10	4.32	3.23	2.93	10.48	....	7.55	6.00	10.46	10.00	28 33	34 00
0.35	......	1.59	1.94	2.05	2.70	8.41	2.42	13.53	....	11.11	11.00	10.60	10.00	26 44	32 00
0.75	......	2.52	3.27	2.46	6.36	3.38	1.56	11.30	....	9.74	10.00	5.97	5.00	25 29	35 00
1.05	......	1.83	2.88	3.28	4.18	3.96	2.65	10.79	....	8.14	8.00	10.18	10.00	26 41	32 00
0.50	......	1.26	1.76	1.64	1.94	5.67	2.24	9.85	9.00	7.61	8.00	4.85	4.00	17 65	25 00
......	......	0.92	0.92	0.82	2.60	6.77	2.91	12.28	10.00	9.37	9.00	2.01	1.75	14 43	22 00
0.19	......	0.91	1.10	1.03	4.80	6.17	2.61	13.08	11.00	10.47	10.00	2.89	1.00	16 58	23 00
0.33	......	2.21	2.54	2.05	5.94	2.17	1.23	9.34	8.00	8.11	7.00	10.94	8.00	25 59	32 00
0.28	......	1.07	1.35	0.21	4.82	4.26	2.08	11.16	10.00	9.08	9.00	3.70	2.00	16 63	20 00

*Potash largely, if not entirely, in form of sulphate.

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
F. W. Tunnell and Co., Philadelphia, Pa.—(Cont.)		
High-Grade Potato Manure	Freehold	3520
Ammoniated Dissolved Bone and Potash	White House Station	3636
Special Fish Guano	Salem	3172
Complete Superphosphate	Flemington	3589
Special Potato Manure	Monmouth Junction	3760
Potato and Grain Special	" "	3761
Royal Fish Compound	" "	3762
The J. E. Tygert Co., Philadelphia, Pa.		
Bone Phosphate	Cedarville	3310
J. E. Tygert and Son, Philadelphia, Pa.		
Ten Per Cent. Sweet Potato Guano	Cape May City	3767
Vineland Grain Co., Vineland, N. J.		
Bone Phosphate	Vineland	3294
Potato Manure	"	3295
J. K. Waddington, Salem, N. J.		
Clover Leaf Phosphate	Salem	3188
George M. Wells, Moorestown, N. J.		
Fish Guano	Riverside	3013
Prosperity Manure	"	3014
High-Grade Potato Manure	"	3015
Tomato and Truck Manure	"	3016
Ten Per Cent. Truck Guano	"	3017
J. Wenderoth and Son, Camden, N. J.		
Ten Per Cent. Fertilizer	Camden	3056
Potato Fertilizer	"	3057
West Jersey Marl and Transporation Co., Sewell, N. J.		
Our Special Sweet Potato Manure	Elmer	3189
Our Special White Potato Manure	Fairton	3215
Our All Crop Mixture	Elmer	3191
Our High-Grade Truck Manure	Fairton	3212
William Wilde, Vineland, N. J.		
Sweet Potato Manure	Vineland	3297
I. S. Yarnall, Media, Pa.		
Cabbage and Potato Manure	Blackwood	3128

Complete Fertilizers

Furnishing Nitrogen, Phosphoric Acid and Potash.

Nitrogen.					Phosphoric Acid.							Potash.			
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.	Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
0.78	......	1.28	2.06	2.46	4.40	4.48	2.14	11.02	9.00	8.88	8.00	9.29	10.00	$23 44	$30 00
......	......	1.55	1.55	0.21	6.32	4.69	2.91	13.92	10.00	11.01	9.00	2.86	2.00	18 77	20 00
0.33	0.20	1.27	1.80	2.05	1.98	5.79	2.75	10.52	9.00	7.77	8.00	3.08	3.00	16 72	25 00
......	......	1.50	1.50	0.82	3.88	5.93	2.66	12.47	10.00	9.81	9.00	3.89	1.75	18 30	23 00
0.71	1.39	0.86	2.96	2.67	7.28	1.62	0.80	9.70	9.00	8.90	8.50	10.66	9.00	27 31	31 00
0.65	.. ...	1.98	2.63	1.44	7.06	3.04	1.25	11.35	8.00	10.10	7.50	5.31	3.50	22 78	28 00
0.57	......	2.06	2.63	1.85	7.50	2.60	1.13	11.23	9.50	10.10	8.50	5.27	3.50	22 75	29 00
......	0.20	1.52	1.72	1.85	7.80	2.13	1.55	11.48	11.00	9.93	9.00	2.39	2.50	17 46	25 00
0.63	......	0.38	1.01	1.23	5 14	1.21	1.12	7.47	8.00	6.35	7.00	10.17	10.00	17 93	29 00
......	......	1.13	1.13	1.03	4.14	4.18	2.27	10.59	10.50	8.32	8.50	1.75	1.50	13 73	25 00
0.56	......	0.99	1.55	1.64	4.34	2.80	1.04	8.18	....	7.14	7.00	9.91	10.00	20 32	30 00
0.44	......	1.08	1.52	1.64	2.94	5.42	2.71	11.07	....	8.36	9.00	3.29	3.00	16 39	25 00
......	......	2.11	2.11	2.05	5.58	2.49	2.25	10.32	....	8.07	8.00	2.10	2.00	17 12	23 00
0.49	......	1.43	1.92	1.85	5.30	2.35	1.22	8.87	....	7.65	7.00	9.99	10.00	22 20	28 00
0.75	0.62	1.74	3.11	2.87	5.46	1.82	1.04	8.32	....	7.28	7.00	9.03	9.00	24 99	30 00
1.19	......	3.37	4.56	4.92	6.36	1.78	1.50	9.64	....	8.14	7.00	3.78	4.00	26 17	33 00
1.97	1.52	3.96	7.45	8.20	3.70	2.04	1.07	6.81	....	5.74	4.00	3.84	4.00	33 55	43 00
2.15	1.79	3.78	7.72	8.20	3.68	1.97	1.31	6.96	6.00	5.65	5.00	3.94	4.00	34 53	47 00
0.97	0.47	1.75	3.19	3.28	6.68	3.09	0.95	10.72	9.00	9.77	7.00	7.20	7.00	25 80	34 00
0.41	......	1.31	1.72	1.64	6.52	1.76	1.33	9.61	....	8.28	8.00	9.44	10.00	21 68	28 00
0.21	......	2.01	2.22	2.46	4.64	2.62	1.48	8.74	....	7.26	6.00	*8.14	8.00	21 86	27 00
......	......	1.85	1.85	2.05	4.64	2.24	1.94	8.82	....	6.88	6.00	4.67	4.00	17 23	23 00
0.50	......	2.52	3.02	3.28	5.40	3.10	1.98	10.48	....	8.50	8.00	8.50	7.00	25 74	31 00
......	......	2.00	2.00	......	4.84	3.42	1.81	10.07	....	8.26	....	8.01	....	21 76	26 00
0.57	......	2.44	3.01	3.28	6.68	1.83	1.27	9.78	....	8.51	7.00	5.15	5.00	22 56	35 00

* Potash largely, if not entirely, in form of sulphate.

2. Ground Bone.

The thirty-four samples of ground bone examined this year are of good quality, and, with a few exceptions, were as guaranteed and were sold at prices very close to Station's valuations. Four samples were not accompanied by a guarantee, although the requirements of the law are quite as exacting with this class of materials as with complete fertilizers. In composition the samples range from 1.37 to 4.97 per cent. of nitrogen, with an average of 3 per cent., and from 19.40 to 28.80 per cent. of phosphoric acid, with an average of 24.41 per cent. A high nitrogen content is usually accompanied by a low phosphoric acid, and *vice versa,* but this relation is not always maintained. There are, too, wide variations in the mechanical condition of the samples; in the finest sample 90 per cent. will pass through a one-fiftieth-inch sieve, and in the coarsest only 30 per cent.

The average fineness and composition of the samples this year, as compared with 1900, 1901 and 1902, is shown as follows:

	Fine	Coarse.	Nitrogen.	Phosphoric Acid.
	%	%	%	%
Average for 1900......	63	37	3.24	23.33
" " 1901......	52	48	3.20	24.20
" " 1902......	57	43	3.05	25.41
" " 1903......	59	41	3.00	24.41

The only change in the Station's schedule for the valuation of bone this year was in the case of the nitrogen in the fine bone, which was increased from 16 to 16.5 cents per pound. The average valuation was $26.37 and the selling price $28.04, a difference of $1.67, or 6.3 per cent. While there are, of course, some exceptions, the average ground bone shows a much closer relation between selling price and valuation than in the case of complete fertilizers.

Miscellaneous Fertilizers and Sundry Materials.

Of the twenty-four samples of miscellaneous fertilizers, three are plain superphosphates, sixteen are plain superphosphates with potash, and five furnish phosphoric acid and nitrogen. In thirteen of these materials the brand name indicates that bone enters into their composition. The presence of the word "bone" in the brand name indicates nothing definite as to the composition of the fertilizer; bone may

or may not have been used, but the absence of nitrogen and the presence of water-soluble phosphoric acid indicates with great certainty that true bone has not been used. The Station has no intention of discriminating against the *use* of acid phosphate, which is the chief or sole component of these materials, but against the *purchase* of it as bone at bone prices.

All of the samples were accompanied by guarantees; in ten cases the available and in three cases the potash failed to reach the guarantee given. With a few exceptions these materials are expensive sources of plant-food. Two of the acid phosphates furnished available phosphoric acid at 4.5 and 4.1 cents per pound, somewhat higher than those reported in an earlier portion of this bulletin; in the third sample available phosphoric acid cost 5.2 cents per pound, much higher than the average price for this material. The sixteen samples of superphosphate with potash furnished plant-food at an average valuation of $13.08, with an average price of $18.53, an advance of $5.45, or 41.7 per cent.; this is even higher than in the case of complete fertilizers. By giving to the potash the regular Station's valuation of 4.25 cents per pound, it is found that the available phosphoric acid in these materials, on the average, cost 8.1 cents per pound, showing what an excessive price the consumer paid for acid phosphate under the guise of bone.

The sundry materials examined include two samples of tannery refuse, two of wool waste, two of sheep manure and one of nitrate of potash. The nitrate of potash, except for its limited output, would be a useful and economical concentrated fertilizer; in the sample examined the nitrogen costs 13 and the potash 4.3 cents per pound.

Ground Bone

Furnishing Nitrogen and Phosphoric Acid.

Station Number.	BRAND.	MANUFACTURER.
3616	Ground Bone	American Agricultural Chem. Co., New York City
3236	Sharpless and Carpenter's Pure Ground Bone	" " " " " " "
3361	Bone Sawings	American Cutlery Co., Keyport, N. J.
3154	Raw Bone Meal	Armour Fertilizer Works, Baltimore, Md
3724	Bone Meal	" " " " "
3759	Bone Meal	" " " " "
3253	Raw Bone Fine	The Berg Co., Philadelphia, Pa.
3201	Market Bone	Bowker Fertilizer Co., Boston, Mass.
3651	Fresh Ground Bone	" " " " "
3480	XXX Ground Bone	E. Frank Coe Co., New York City
3518	Bone Meal	Denise and Denise, Freehold, N. J.
3012	Steamed Bone	J. Y. Dilatush, Robbinsville, N. J.
3574	Fine Ground Bone	Hill and Co., Flemington, N. J.
3598	Pure Ground Bone	Ira Hill, Copper Hill, N. J.
3373	Pure Raw Bone Meal	Lister's Agricultural Chem. Works, Newark, N. J.
3734	Pure Ground Bone	The Mapes F. and P. Guano Co., New York City
3339	Steamed Bone	The D. B. Martin Co., Philadelphia, Pa.
3325	Ground Bone	Monmouth Chemical Works, Shrewsbury, N. J.
3207	Button Bone Dust	L. Moritz, Philadelphia, Pa.
3486	Steamed Bone	Nassau Fertilizer Co., New York City
3487	Raw Bone Meal	Albert Nelson and Co., Allentown, N. J.
3665	Ground Bone	Ruckman Bros., New Brunswick, N. J.
3584	Pure Bone Meal	Scott Fertilizer Co., Elkton, Md.
3586	Pure Ground Raw Bone	" " " " "
3208	Swift-Sure Bone Meal	M. L. Shoemaker and Co., Philadelphia, Pa.
3051	Button Bone Dust	Taylor Bros., Camden, N. J.
3467	Ground Bone	The Taylor Provision Co., Trenton, N. J.
3469	Ground Steamed Bone	" " " " " "
3211	Pure Ground Bone	I. P. Thomas and Son Co., Philadelphia, Pa.
3498	Pure Fine Ground Bone	Trenton Bone Fertilizer Co., Trenton, N. J.
3187	Button Bone Dust	Emil Wahl Mfg. Co., Philadelphia, Pa.
3216	Strictly Pure Raw Bone Meal	West Jersey Marl and Trans. Co., Sewell, N. J.
3298	Ground Bone	William Wilde, Vineland, N. J.
3296	Bone Sawings	Winterbottom, Carter and Co., Egg Harbor City, N. J.

Ground Bone

Furnishing Nitrogen and Phosphoric Acid.

WHERE SAMPLED.	Station Number.	Mechanical Analysis.		Chemical Analysis.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
		Finer than 1-50th in.	Coarser than 1-50th in.	Nitrogen.	Phosphoric Acid.		
Woodbine	3616	56	44	3.16	21.24	$24 30	$22 00
Vineland	3236	65	35	2.97	20.54	23 89	27 00
Keyport	3361	90	10	3.89	26.76	33 36	26 00
Salem	3154	63	37	2.99	25.64	27 47	30 00
Morristown	3724	56	44	2.37	28.80	27 39	28 00
Pittstown	3759	70	30	2.79	26.42	28 01	28 00
Hammonton	3253	40	60	3.26	25.20	26 12	30 00
Bridgeton	3201	61	39	1.37	27.16	23 65	29 00
Montclair	3651	54	46	2.51	27.24	26 54	40 00
Hightstown	3480	61	39	2.04	28.46	26 56	28 00
Freehold	3518	30	70	3.55	24.16	25 43	23 50
Hightstown	3012	63	37	2.56	22.52	23 95	25 00
Flemington	3574	53	47	2.85	22.54	24 11	27 00
Copper Hill	3598	56	44	3.17	24.58	26 71	27 00
Matawan	3373	62	38	2.43	27.54	27 13	34 00
Morristown	3734	36	64	4.03	24.22	27 26	32 00
Moorestown	3339	59	41	1.87	21.90	21 21	19 00
Shrewsbury	3325	65	35	3.55	19.40	24 76	25 00
Bridgeton	3207	77	23	2.82	25.98	28 31	28 00
Hightstown	3486	65	35	2.40	26.36	26 41	24 00
Windsor	3487	46	54	3.68	22.98	26 26	30 00
New Brunswick	3665	42	58	3.55	24.78	26 81	28 00
Flemington	3584	65	35	3.97	21.26	27 37	28 00
"	3586	37	63	3.80	22.16	25 33	30 00
Bridgeton	3208	61	39	4.97	24.36	32 20	32 00
Camden	3051	76	24	2.75	25.60	27 73	27 00
Trenton	3467	54	46	3.59	22.16	26 05	29 50
"	3469	62	38	1.79	24.12	22 75	27 50
Bridgeton	3211	64	36	1.62	26.52	24 13	28 00
Hightstown	3498	54	46	4.18	24.10	29 13	30 00
Elmer	3187	62	38	3 28	24.72	27 59	26 00
Fairton	3216	41	59	3.95	21.06	25 30	29 00
Vineland	3298	64	36	1.52	23.32	21 50	25 00
Egg Harbor City	3296	89	11	3.58	26.18	31 84	27 00

Miscellaneous Fertilizers

Furnishing Nitrogen, Phosphoric Acid or Potash.

MANUFACTURER AND BRAND.	WHERE SAMPLED.	Station Number.
American Agricultural Chemical Co., N. Y. City.		
Great Eastern Soluble Bone and Potash	Millstone	3348
Quinnipiac Soluble Dissolved Bone	Everittstown	3562
" Dissolved Bone and Potash	Washington	3720
Read's Alkaline Bone	Three Bridges	3608
Wheeler's Wheat and Clover Fertilizer	Cold Spring	3239
Williams and Clark's Dissolved Bone and Potash	Ringoes	3611
" " " Peach Tree Special	Martinville	3475
Armour Fertilizer Works, Baltimore, Md.		
Star Phosphate	Bound Brook	3621
Bowker Fertilizer Co., Boston, Mass.		
Superphosphate with Potash	New Germantown	3641
E. Frank Coe Co., New York City.		
High-Grade Dissolved Bone and Potash	Hightstown	3479
Wyckoff Hendrickson, Allentown, N. J.		
Grass Mixture	Robbinsville	3416
S. M. Hess and Bro., Philadelphia, Pa.		
Farmers' Cereal King	Ringoes	3595
Lister's Agricultural Chemical Works, Newark, N. J.		
Animal Bone and Potash	Middlebush	3349
" " " " No. 2	Riverside Station	3603
Nassau Fertilizer Co., New York City.		
Alkaline Bone	Monmouth Junction	3433
Soluble Bone Phosphate	Neshanic	3580
Special Corn Fertilizer	"	3581
R. H. Pollock, Baltimore, Md.		
Victor Bone Phosphate	Egg Harbor City	3285
I. P. Thomas and Son Co., Philadelphia, Pa.		
Alkaline Bone	Titusville	3066
Improved Animal Bone	"	3073
Special Dissolved Bone and Potash	White House Station	3632
Trenton Bone Fertilizer Co., Trenton, N. J.		
Dissolved Tankage	Newton	3746
Top Dressing for Grass	Frenchtown	3573
F. W. Tunnell and Co., Philadelphia, Pa.		
Acidulated Animal Bone	White House Station	3634

Miscellaneous Fertilizers

Furnishing Nitrogen, Phosphoric Acid or Potash.

Nitrogen.					Phosphoric Acid.							Potash.		Value of 2,000 lbs. at Station's Prices.	Selling Price of 2,000 lbs. at Consumers' Depot.
										Available.					
From Nitrates.	From Ammonia Salts.	From Organic Matter.	Total Found.	Total Guaranteed.	Soluble in Water.	Soluble in Ammonium Citrate.	Insoluble.	Total Found.	Total Guaranteed.	Found.	Guaranteed.	Found.	Guaranteed.		
......	......	......	......	......	5.54	4.89	2.73	13.16	11.00	10.43	10.00	1.88	2.00	$12 08	$13 50
......	......	......	......	......	11.92	3.60	1.51	17.03	15.00	15.52	14.00	......	......	†5.2	16 00
......	......	......	......	......	8.68	1.45	0.64	10.77	11.00	10.13	10.00	2.28	2.00	11 32	18 00
......	......	......	......	......	6.32	3.40	2.19	11.91	11.00	9.72	10.00	2.29	2.00	11 58	17 00
......	......	......	......	......	4.44	4.83	1.80	11.07	11.00	9.27	10.00	1.93	2.00	10 70	17 00
......	......	......	......	......	5.78	3.87	3.22	12.87	11.00	9.65	10.00	2.00	2.00	11 67	16 00
......	......	......	......	......	7.50	2.91	2.03	12.44	11.00	10.41	10.00	7.39	8.00	16 46	23 00
......	......	......	......	......	13.16	2.24	0.34	15.74	16.00	15.40	14.00	......	......	†4.5	14 00
......	......	......	......	......	1.06	8.34	4.59	13.99	12.00	9.40	10.00	1.23	1.00	11 35	13 50
......	......	......	......	......	8.18	2.12	2.45	12.75	12.50	10.30	10.50	6.34	2.00	15 64	21 00
6.92	......	3.24	10.16	9.84	......	3.49	2.82	6.31	......	3.49	5.00	......	......	36 05	40 00
......	......	......	......	......	7.78	3.87	1.54	13.19	13.00	11.65	12.00	4.18	3.00	14 74	19 00
......	......	......	......	......	4.10	3.91	2.56	10.60	10.00	8.04	9.00	4.38	5.00	11 98	21 00
......	......	......	......	......	6.74	2.49	2.34	11.57	11.00	9.23	10.00	*1.90	2.00	11 15	19 00
......	......	......	......	......	7.98	3.32	1.25	12.55	10.80	11.30	10.00	5.95	5.00	15 73	19 00
......	......	......	......	......	11.26	3.31	2.04	16.64	15.00	14.60	14.00	......	......	†4.1	12 00
......	......	......	......	......	6.90	3.40	2.36	12.66	11.00	10.30	10.00	4.54	5.00	14 07	17 00
......	......	......	......	......	3.12	4.57	3.57	11.23	10.00	7.69	9.00	1.13	1.00	9 31	17 50
......	......	......	......	......	5.90	3.66	1.46	11.02	12.00	9.56	10.00	2.60	2.00	11 39	25 00
......	......	1.50	1.50	1.64	3.46	6.04	9.52	19.02	20.00	9.50	10.00	......	......	17 46	26 00
......	......	......	......	......	6.78	3.00	1.87	11.65	12.00	9.78	10.00	2.11	2.00	11 34	20 00
......	......	3.61	3.61	3.69	7.14	5.63	0.83	13.60	10.50	12.77	9.50	......	......	24 10	30 00
9.33	......	2.07	11.40	11.48	0.80	3.07	1.24	5.11	......	3.87	4.00	......	......	39 01	44 00
......	0.26	2.11	2.37	1.64	1 22	8.59	8.19	18.00	20.00	9.81	10.00	......	......	20 19	25 00

* Potash in the form of sulphate. † Cost in cents per pound of available phosphoric acid.

Sundry Materials.

3005. Inner Coating of Hides. Made by Henry Wise, Philadelphia, Pa. Sent by S. C. De Cou, West Moorestown.

3698. Tannery Refuse. Sent by F. E. Woodruff, Cranford.

3311. Wool Waste. Sent by E. S. Dobbs, Mt. Ephraim.

3312. Wool Waste. Old waste with hide scrapings. Sent by E. S. Dobbs, Mt. Ephraim.

3314. Sheep Manure. From stock of Monmouth Chemical Works, Shrewsbury.

3386. Sheep Manure. From stock of the Taylor Provision Co., Trenton.

3749. Nitrate of Potash. From stock of E. Mortimer & Co., New York City. Sent by C. G. MacMurray, Westfield.

	3005	3698	3311	3312	3314	3386	3749
	%	%	%	%	%	%	%
Nitrogen	5.45	4.35	2.21	1.18	1.87	2.96	*11.92
Phosphoric Acid	0.09	0.45	0.21	0.45	0.76	2.27	.....
Potash	0.30	0.13	3.32	0.19	1.49	1.51	43.96
Selling price per ton	$5.00	....	$3.00	$1.75	$30.00	$20.00	$69.00

* In the form of nitrates.

The following eight samples were received too late to be included in Bulletin 168, and are therefore published here as a matter of record.

3770. Bellemeade Grange Mixture No. 1. Made by American Agricultural Chemical Co., New York City. Sent by P. A. Garretson, Bellemeade.

3771. Bellemeade Grange Mixture No. 3. Made by American Agricultural Chemical Co., New York City. Sent by P. A. Garretson, Bellemeade.

3772. Bellemeade Grange Mixture No. 4. Made by American Agricultural Chemical Co., New York City. Sent by P. A. Garretson, Bellemeade.

3773. Bellemeade Grange Mixture No. 9. Made by American Agricultural Chemical Co., New York City. Sent by P. A. Garretson, Bellemeade.

3774. Bellemeade Grange Mixture for Potatoes, No. 1. Made by American Agricultural Chemical Co., New York City. Sent by P. A. Garretson, Bellemeade.

3777. Crude Fish and Tankage. Made by F. W. Tunnell & Co., Philadelphia, Pa. Sent by the G. Q. Hammell Co., Delanco.

	3770	3771	3772	3773	3774	3777
Nitrogen from nitrates	....	....	....	....	....	....
" " ammonia salts	0.75	....	....	....	1.18	....
" " organic matter	1.16	1.07	1.35	....	2.02	3.40
" total found	1.91	1.07	1.35	....	3.20	3.40
" " guaranteed	1.64	0.82	1.23	....	3.28	4.10
Phosphoric Acid, soluble	5.08	7.68	4.88	7.32	5.92	0.72
" " reverted	2.65	1.70	2.20	2.14	2.57	3.23
" " insoluble	2.49	2.18	2.60	2.58	2.15	0.81
" " total found	10.22	11.56	9.68	12.04	10.64	4.76
" " " guaranteed	9.00	10.00	7.00	11.00	9.00	....
" " available found	7.73	9.38	7.08	9.46	8.49	3.95
" " " guaranteed	8.00	9.00	6.00	10.00	8.00	4.00
Potash found	9.39	6.98	5.69	7.03	7.28	....
" guaranteed	10.00	7.00	5.00	8.00	7.00	....
Value of 2,000 pounds	$22 51	$18 88	$16 84	$15 53	$25 69	$15 44
Selling price of 2,000 pounds	$24 50	$21 40	$18 60	$16 50	$26 50	$19 00

FODDERS AND FEEDS.

I.

CONCENTRATED FEEDING STUFFS.

On the following pages is presented the work of the Station in the examination of concentrated feeding stuffs for the third season under the law of March 15th, 1900. The particulars of this law and the methods of carrying out its provisions have been fully described in Bulletins Nos. 153 and 160, to be had upon request, and will not be repeated here. For the same reason the new reader is referred to those bulletins for the description of manufacturing processes and for other matter which was properly introductory to a work of this character, but whose importance does not warrant its repetition at this time.

The Classification of Feeds.

The purpose of the law, by authority of which this work is done, is twofold—*first,* it is to the effect that certain feeds shall be guaranteed, and guaranteed correctly; *second,* it is to guard from adulteration. The work of the Station, therefore, consists in verifying the accuracy of the guarantees and in determining the purity of feeding stuffs generally. The Station has, during the previous two years, examined the guaranteed goods quite exhaustively, not to prove the guarantees alone, but also to determine the uniformity of this class of goods. This year, therefore, it has examined the guaraneed goods but moderately, and has made a rather extended, if not complete, examination of the various kinds and grades of wheat middlings. Thus, of the 661 samples received 332, or more than half, belong to the unguaranteed class, and 217 of these are samples of some form of wheat middlings or else of feeding flour.

Guarantees and Actual Composition.

Of the 327 samples received, all of which should have been accompanied by a guarantee, 156 were found to be otherwise; in the case of 127 of these, however, the guarantees were filed at the Experiment Station by the manufacturer, and will be published in the tables of analyses for the information of all concerned. Nevertheless, it must not be considered that the filing of this information with us is a substitute for a guarantee which is missing in the sale of the goods. In most cases the manufacturers, however, are not at fault, as often the dealers are careless with the tags.

The 327 samples received represent 122 individual brands. Of these brands 107 are accompanied by guarantees in the case of every one of the samples; one is guaranteed in some of the samples, but not in others, and fourteen brands are in every case devoid of tag, statement or information of any character. This is less than 12 per cent. of the total number received, whereas last year 13 per cent. and at the first inspection the previous year 32 per cent. were so devoid.

The brands examined this year are represented by 233 samples. Of these nineteen are not accompanied by a guarantee of either protein or fat, and two others are similarly deficient in the case of the fat only. The guarantees, when given, are fulfilled in 145 cases. In other words, 68 per cent. of the samples guaranteed fulfill their promises. This figure is identical with that of last year.

The samples defective this year, in addition to the twenty-one without guarantees, are thirty-two which do not contain the amount of protein promised, nineteen similarly deficient in fat and eighteen in both protein and fat. There are, therefore, in a possible 214, but fifty cases of a deficiency in protein, the most important constituent of a purchased feed. Dairymen and other feeders of the State, may, therefore, be congratulated on the effectiveness of the law providing a feed inspection, even though the same is in the infancy of its operation. In most of the cases where guarantees are lacking, and in many where they are not fulfilled, the same names are recognized from year to year; those who have once affixed guarantees seem to continue to do so, and as for the others, pressure could very profitably come from the

customer. If consumers will insist on guarantees when guarantees are due, an unguaranteed feed will soon be as rare as an unguaranteed fertilizer.

The Purity of the Feeds.

In the case of a feed which is guaranteed the main point is whether the guarantee is fulfilled. If the manufacturer delivers the total amount of nutrients guaranteed, it would seem as if enough has been done, and nothing can be said if the sample is contaminated. Nevertheless, the use of names used in the trade is, in a sense, a guarantee of a specific composition, and such materials should not be contaminated. A number of such contaminations are to be observed throughout the guaranteed goods. In many cases the samples thus affected are below guarantee, or carry none at all. Malt sprouts this year seem to be affected in this way more than the other feeds, as they contain in a number of cases excessive amounts of hulls, one sample in particular containing finely-ground rice hulls. This sample was not guaranteed. In the feed mixture put up by the same dealer rice hulls was frankly acknowledged as an ingredient. The use of rice hulls at any time is to be condemned.

In this connection the Station desires to express its regret for an error which crept into the Annual Report for 1902. On page 64 of Bulletin No. 160 two samples of shorts and one of brown middlings were marked with asterisks to show that they were omitted from the averages; the two shorts varied in composition from the others in the table, and were therefore omitted, but, nevertheless, they were pure; the brown middlings, however, contained rice hulls. When this matter was reprinted in the Annual Report this information was appended in a footnote intended to apply to the last sample only, but as the two other samples also had asterisks, it seemed to apply to them also, and thus an injustice was unintentionally done to those two samples. To Messrs. C. H. Snyder & Son, of Freehold, and the Ewen Milling Company, of Alloway, the manufacturers of these feeds, our apologies are respectfully presented.

The departure from normal composition has been due this year to two causes, namely, (1) actual adulteration, as, for example, the addition of rice hulls to malt sprouts, as noted; and (2) the imper-

fect separation of the parts of the grain, as, for instance, when a middlings contains more flour than is usual. The variations from normal, and the flagrant adulterations are stated in detail in a subsequent portion of this bulletin, and may be summarized as follows:

1 Gluten Feed is practically a corn bran.
1 Gluten Feed contains a little corn cob.
1 Hominy Meal contains corn bran.
1 Hominy Meal contains a little oats.
1 Cerealine Feed is practically a coarse hominy.
1 Cerealine Feed is practically a corn bran.
1 Maizeline Feed is practically a corn bran.
1 Maizeline Feed contains a little oats.
3 Malt Sprouts contain barley hulls in excess.
1 Malt Sprouts contains malt and hulls in excess.
1 Malt Sprouts contains considerable malt.
1 Malt Sprouts contains much ground rice hulls.
1 Local Feed Mixture contains oats and barley, instead of Marsden Feeds, as stated.
1 Local Feed Mixture contains rice hulls,
1 Local Feed Mixture contains oats, instead of dried brewers' grains, as stated.
2 Wheat Brans show traces of oats.
1 Wheat Bran contains chaff, rye and weed seeds.
1 Wheat Feed contains corn cob.
10 White Middlings contain excess of wheat flour.
2 Red Dog Flours contain excess of wheat flour.
1 Brown Middlings contains considerable hominy meal.
1 Barley Feed contains oat hulls.
4 Buckwheat Brans contain buckwheat hulls in excess.
1 Corn and Oats contains oat hulls in excess.
3 Corn and Oats contain traces of wheat.
1 Corn and Oats contains much wheaten material.

While thus there are many innocent contaminations and a few flagrant adulterations, it remains a matter of congratulation that, in a season when feeds have been high and scarce and farmers have been obliged to buy through the exhaustion of their own stores of fodder, no greater number of departures from normal composition have been noted. It is still further gratifying that our inspector has this year found no stock for sale as such of any of the low-grade feeds, or roughages, which, furnishing less than 7 per cent. of protein, were last year designated as "feed substitutes."

Average Composition and Selling Prices.

The following table shows the average selling prices of the several feeds, with their average composition, arranged in the order of their protein content:

	Protein. %	Fat. %	Selling Price.
Cottonseed Meal	44.08	10.64	$29 85
Linseed Meal (New Process)	37.25	3.37	30 00
Chicago Gluten Meal	36.41	2.54	31 00
Atlas Gluten Meal	34.99	15.67	25 00
Linseed Meal (Old Process)	34.77	8.37	32 27
Ajax Feed	30.41	13.34	22 00
Dried Brewers' Grains	27.41	7.29	20 06
Globe Gluten Feed	26.32	3.10	26 26
Buffalo Gluten Feed	25.83	3.16	25 54
Malt Sprouts	25.48	2.33	18 69
Buckwheat Middlings or Bran	24.95	7.13	20 13
Queen Gluten Feed	24.53	2.60	25 64
Grano Gluten Feed	22.99	8.56	22 00
Red Dog Flour	19.27	5.20	27 40
Flour Middlings	19.12	5.38	25 97
Dried Distillers' Grains	18.99	9.09	18 50
H. O. Dairy Feed	18.57	4.62	29 33
Dried Brewers' Grains and Molasses	17.69	2.57	20 50
Wheat Middlings	17.21	4.92	25 28
Wheat Feed	17.05	4.63	22 26
Barley Meal	16.79	4.60	22 00
Wheat Bran (Winter)	16.52	4.43	21 90
Wheat Bran (Spring)	16.32	5.39	22 33
Germ Oil Meal	15.66	39.31	24 00
Quaker Dairy Feed	15.00	3.64	20 44
Barley Feed	14.19	4.81	26 00
Peanut Vine	13.88	12.20	.....
Rye Middlings	13.87	2.72	24 25
H. O. Horse Feed	13.70	4.25	30 00
Corn, Oats and Barley Feed	13.11	5.66	28 67
Fancy Corn Bran	12.30	2.99	19 56
Local Mixtures	12.12	5.13	25 91
Cerealine Feed	11.59	8.94	24 86
Hominy Meal or Feed	11.47	9.12	25 62
Maizeline Feed	11.44	7.88	26 50
Corn Bran (Sugar Feed)	11.01	4.17	20 17
Excelsior Feed	10.94	5.53	25 00
G. W. Dairy Feed	10.70	2.96	19 00
Monarch Chop Feed	10.55	4.99	25 00
Van Winkle's Gluten Feed	10.31	4.49	22 00
Horse Feeds (Whole Grains)	10.17	3.67	27 81
Yellow Feed	10.04	3.43	24 00

	Protein. %	Fat. %	Selling Price.
Corn and Oats (Provender)	9.97	3.95	$28 57
Victor Corn and Oats Feed	9.80	4.68	22 90
Rye Feed or Chop	9.75	1.74	24 36
Diamond Corn and Oats Feed	9.69	5.80	29 00
Peanut Middlings	9.68	6.53	.....
Buffalo Stock Feed	9.13	4.56	25 00
Cottonseed Feed	9.00	2.37	18 00
Boss Corn and Oats Feed	8.73	4.05	22 30
Star Chop	8.53	3.70	27 00
Peanut Bran	8.47	4.36	.....
Vim Oat Feed	8.23	3.22	15 60
Northern Oat Feed	7.94	2.82	17 00
Hunter's Oat Feed	7.69	3.05	13 50
Royal Oat Feed	7.51	2.84	16 57
Atlas Corn Bran (Wet)	5.45	3.28	11 77
Ground Meat and Poultry Feeds.			
Darling's Beef Meal	59.94	10.41	47 00
Shoemaker's Ground Meat	56.03	12.46	52 00
Shuster's Ground Meat	47.46	18.77	50 00
Bowker's Animal Meal	31.76	9.35	42 50
Blatchford's Calf Meal	25.38	4.90	70 00
H. & L. Poultry Feed	17.42	7.50	35 00
H. O. Poultry Feed	16.42	5.23	32 00
American Poultry Feed	14.38	6.73	30 00

The Selection of Feeds.

An inspection of the foregoing table shows the well-known fact very clearly that the price of a feed is no index to its value from the standpoint either of nutrients contained or of suitability to the usual farm purposes. The price of a feed is, therefore, to be made a secondary consideration in the selection of feeds. Successful practice demands the purchase of *protein,* for the reason that the hay, corn, fodder, ensilage, etc., of which the farmer should have an abundance, are deficient in that ingredient. Materials which are low in protein should, therefore, appeal only to the city feeders of horses and stall-fed cattle, or to others who, of necessity, must purchase *all* their feeding material.

It remains for the purchaser to select, bearing this distinction in mind. The list from which his selection may be made is composed of five pretty well defined groups. They range in protein content from more than 40 per cent. to less than 8 per cent. The groups may be outlined as follows:

1. Cottonseed, linseed, Chicago and Atlas Gluten Meals and Ajax Feed (a high-grade distillery grains), furnishing from 30 to 44 per cent. of protein, and costing from $22 to $32 per ton.

2. The by-products of the manufacture of starch, glucose, spirits and beer, and buckwheat bran and middlings, furnishing from 23 to 27 per cent. of protein, and costing, approximately, from $18 to $26 per ton.

3. The wheat and rye brans, middlings and feed, etc., and the H. O. Dairy and Quaker Dairy Feeds, furnishing from 15 to 19 per cent. of protein, and costing from $19 to $29 per ton.

4. Corn bran (sugar feed), cerealine feed, maizeline feed, hominy feed, and the artificial feed mixtures, furnishing from 10 to 15 per cent. of protein, and costing from $19 to $30 per ton.

5. Low-grade feeds, largely oat chop and oat hulls, or oats with large admixtures of corn, furnishing from 7 to 10 per cent. of protein, at from $13 to $29 per ton, and consisting, in many cases, of fiber (hulls, etc.) to the extent of one-fourth their weight.

Summary.

1. Of the 122 distinct brands of feed received, and which should be guaranteed, fourteen are devoid of tag, statement or guarantee.

2. Consumers are advised to purchase nothing unless with the material is furnished the definite guarantee which the law requires shall accompany all kinds of feed, except a few products, like bran, middlings, corn meal, etc.

3. Of the 214 samples which are guaranteed, and of which an examination has been made, sixty-nine fail in their promises, fifty of these being deficient in protein.

4. Among the 242 samples of feeds not required to be guaranteed, 215 are found to be of normal composition, about twenty-four vary from the same, for various reasons, and three are adulterated.

5. Particularly to be avoided are the materials which contain hulls of other seeds or of their own in excess of that normally present.

6. In buying feeds to supplement his home-grown supply the dairyman's aim should be to secure digestible and palatable protein on the most reasonable terms and in the most economical forms. Fully one-half of the different and distinct kinds or brands of feeds in the tables do not meet his requirements in this respect. Therefore, study the composition of feeds as shown in their guarantees and the table of analyses.

DETAILED DISCUSSION OF THE SAMPLES.

FEEDS REQUIRING GUARANTEES.

Cottonseed Meal.

The thirteen samples analysed this year represent five distinct brands. But one sample, No. 3,467, is materially below guarantee in protein; it contains some hulls and is rather dark in color. Two other samples of the same brand and one of another have the same appearance, however, but give in full the amounts of protein guaranteed. None of the samples is low in fat. The average price of all the cottonseed samples is $29.85; the average a year ago was $30.24.

Linseed Meal.

There were thirteen samples of linseed meal analysed this year; of these one is a sample of "New Process" Meal, which is characterized by its low content of residual oil. All of the samples contain the amounts of protein and fat guaranteed, and some exceed the same materially. The average price of linseed meal is $32.27; a year ago the average was $36.26.

Germ Meal.

But one sample of germ meal has been received. It consists, essentially, of the entire germ from which the oil has not been expressed. The removal of the oil would improve this product, by narrowing its nutritive ratio, and render it more suitable for one of the components of a ration. No samples of germ oil meal have been received this year.

Chicago Gluten Meal.

Two samples of this material have been received and analysed. Both are actually below guarantee in both protein and fat, but by our allowance of one per cent. in the protein and one-half per cent. in the fat, two of the shortages are disregarded. The protein in both of these samples is higher than it averaged a year ago, but is, nevertheless, below guarantee, because the manufacturer places his guarantee too high. The average price of Chicago gluten meal is $31; last year it was $29.50.

Gluten Feed.

Three distinct brands of true gluten feed have been received this year, Buffalo, Queen and Globe, of the first of which twelve samples have been analysed, and of the other two, seven and ten, respectively. In addition, two samples without brand names have been received. In the case of the gluten feed, it seems a pity that a material of so much merit should be put on the market with a guarantee that is not only erratic, but also higher than the composition warrants. This condition of affairs compels the statement that eight of the twelve samples of Buffalo Gluten Feed, six of the seven samples of Queen Gluten Feed and four of the ten samples of Globe Gluten Feed are below guarantee in protein. In the first brand there is no material shortage in fat; in each of the other two, four samples are deficient, three of each being deficient in protein also.

In a number of cases the samples with lower analyses are observed to contain somewhat more of the fibrous component than usual. The average analyses of these materials are not far apart, ranging from 24.53 to 26.32 per cent. of protein, and from 2.60 to 3.16 per cent. of fat. The average prices range from $25.54 to $26.26 per ton. A year ago the average price of Buffalo Gluten Feed was $27.14.

The two odd samples of gluten feed are defective. The one carries a guarantee of about one-half the amount of protein which is usually found in gluten feed; the other has no guarantee at all. The former does not reach its guarantee, and is practically all corn bran; the latter is low grade, and slightly contaminated with corn cob.

Hominy Meal.

Twenty-one samples of hominy meal have been analysed; these represent the stock of thirteen manufacturers or brokers. Three samples have no guarantees, but are, nevertheless, of average composition; of the remaining eighteen, two are materially below guarantee in protein content and one in fat content. The latter contains considerable corn bran; the former two are clean average samples, but guaranteed too high. Five of the samples show traces of oats, No. 3,003 particularly, which accounts no doubt for its differing from its duplicate sample in analysis. With the exception of No. 3,003 and No. 3,066, which contains the bran, and is probably a cerealine feed, the samples

range in protein from 10.24 to 12.19 per cent., and in fat from 7.54 to 11.16 per cent. The average price this year is $25.62; last year it was $27.77.

Cerealine and Maizeline Feeds.

Six samples of cerealine feed and two samples of maizeline feed have been analysed. In the case of the former there are two sets of guarantees and two samples which were sold without guarantee. Both maizeline and cerealine feeds appear to consist of white corn bran, some samples containing more or less of the grain itself. One of the unguaranteed samples, No. 3,539, contains, on the other hand, no bran, and is similar to a coarse hominy. The other, No. 3,346, however, contains considerable of the bran, and is the sample of lowest protein and fat content, except one of the maizeline samples, No. 3,551, which is entirely corn bran. The latter is below guarantee in both protein and fat. The other maizeline feed contains a little oats and is higher in composition. The average price this year is $26.50 for maizeline feed and $24.86 for cerealine feed. Last year these prices were $26.75 and $27.69, respectively.

Fancy Corn Bran and Corn Bran, or Sugar Feed.

Six samples of "fancy" corn bran and three of sugar feed have been analysed. The distinction between these two lies in the protein, which, in the former, is guaranteed as high as 14 per cent. But two of the "fancy" corn brans reach the guarantee of protein, however, and these are low in fat. They shade off to the composition of the sugar feed, which is guaranteed lower, with guarantees fulfilled. The distinction between sugar feed and corn bran does not appear in their prices, which average this year at $19.56 for the fancy and $20.17 for the sugar feed. Sugar feed a year ago was sold, on the average, for $19.66.

One sample, No. 3,599, shows the composition of sugar feed, purchased and sampled in the wet condition. This sample contained 40 per cent. of water when received. It does not require a guarantee, but is inserted in the table of sugar feed for information and comparison.

Distillers' Grains.

Three samples of Atlas Gluten Meal have been analysed; notwithstanding the title, this material has not been grouped with the gluten meals, as it is a distillery residue. It consists of corn to a large degree, however. The samples contain a high percentage of protein and fat, 34.99 and 15.67, respectively. One sample, however, is materially below guarantee of protein. The average price of Atlas Gluten Meal is $25.

Ajax Feed, likewise, is a corn distillery grains, and contains 30.41 per cent. of protein, not reaching its guarantee of 34 per cent. The sample of Grano Gluten Feed, a distillers' grains, and that marked simply "distillers' grains" both reach guarantees. These three feeds have been sold at $22, $22 and $18.50, respectively. Distillers' grains last year sold at $21.67.

Malt Sprouts.

Thirty-three samples of malt sprouts have been analysed. Of these, ten have no guarantee whatever, five do not reach their guarantees of protein, four do not reach their guarantees of fat, and two are deficient in both protein and fat.

Six of the thirty-three samples of this material are contaminated, three containing excessive amounts (22 to 28 per cent.) of barley hulls, one containing malt as well as hulls, one containing malt only, and one containing a large amount of finely-ground rice hulls. Four of the contaminations occur in the unguaranteed samples. Nos. 3,215 and 3,176, of F. W. Goeke & Company, and No. 3,074, of unknown source, but from the stock of Meyer & De Vogel, contain the excess of barley hulls; and No. 3,072, of J. D. Macky, and from the stock of Joseph English, contains the rice hulls. The other contaminated samples, Nos. 3,005 and 3,536, are guaranteed; the former does not come up to guarantee, nor to the analysis of the three other samples from the same source, by reason of containing considerable malt, together with barley hulls; the latter is likewise below guarantee, and contains considerable malt. The remaining six unguaranteed samples and the five others below guarantee of protein are, nevertheless, of good average quality. The average protein in malt sprouts is 25.48 per cent., and the average price $18.69; last year the latter was $21.

Dried Brewers' Grains.

Twenty-two samples of dried brewers' grains have been analysed. One sample carries no guarantee of fat, but is well up in that ingredient; four are low in protein, two in fat, and one in both protein and fat. The average price is $20.06; last year it was $22.91.

The single sample of dried brewers' grains mixed with molasses is below guarantee in protein.

Feed Mixtures.

Two samples of corn, oats and barley feed have been analysed, and found up to guarantee. The price of this material is $28.67 per ton; last year it was $30.75.

The sample of cottonseed feed, which consists mostly of hulls and lint, is below guarantee in both protein and fat, and sold for $18, as compared with $15 a year ago.

Local Feed Mixtures.

Twenty-two local feed mixtures have been analysed; with ten of these were furnished the guarantees of protein and fat, and with twelve the ingredients used were given; five of the former specified their ingredients as well. The twelve unguaranteed samples are tabulated separately and the guarantees supplied by the Station by calculation from the ingredients used. In but one case of these has it been found that the ingredients are wrongly stated, viz., No. 3,367, in which oats are found instead of brewers' grains, thus lowering the percentage of protein and fat. In one of the guaranteed feeds, however, No. 3,305, whose ingredients also are given, oats and barley are found instead of the Marsden feeds, but this has improved the composition. The local mixtures in New Jersey can be said, therefore, to maintain their excellent showing of last year. The Station would hardly advise the use of rice hulls in sample 3,067, however, even though the fact is made known to the consumer. The average price of these mixtures is $25.91; last year it was $26.97.

Oat Feeds and Corn and Oat Feeds.

Under this classification are included the feed mixtures, which consist principally of oat "feed," light oats, or oat hulls; many of the local feed mixtures just discussed also contain these materials to a greater or less extent.

In previous bulletins the Station has declared its position in the matter of oat hulls. The presence of this material in the feeds which come from the manufacturers of cereal food for man is recognized, and although it occurs to the extent of from 40 to even 70 per cent. of the sample, consumers no doubt purchase with an understanding of this fact. So far as the present discussion is concerned, the only material question is whether they are guaranteed and their guarantees are fulfilled. The three products of the American Cereal Company, viz., Quaker Dairy Feed, Victor Corn and Oat Feed and Vim Oat Feed, furnishing three distinct grades, are found as guaranteed in every case; and likewise the sample of stock feed from the Buffalo Cereal Company; that of Excelsior Feed from F. A. Champlin & Company; that of corn and oats, of the Diamond Mills; the samples of H. O. Dairy Feed; of Hunter Bros.' Oat Feed, and of Monarch Chop Feed.

The three products of the Great Western Cereal Company, viz., Boss Corn and Oats Feed, Dairy Feed and Royal Oat Feed, show considerable variability in composition. In one sample of the first brand the fat is lower than guaranteed; in one of the second the protein is low, and in two of the third both protein and fat are deficient. In the case of the last two brands the deficiencies are no doubt due to their large content of oat hulls, these samples containing considerably more of this material than their duplicates.

The H. O. Dairy Feed and H. O. Horse Feed are uniformly up to guarantee of protein, but one of the latter is low in fat; the protein being higher than usual, would indicate imperfect mixing. These feeds this year contain a peanut product, while neither cottonseed nor linseed meal has been found, as formerly.

The Northern Milling Company's Oat Feed is low in fat, and exceeds guarantee in protein; the Miner Hilliard Star Chop is low in both of these ingredients; J. C. Smith & Wallace's "Yellow Feed" is unguaranteed. The latter consists of corn and oats.

The prices of these feed mixtures, like their composition, is variable, with no constant relation between nutriment offered and price asked. On the average about $22 is asked for from 10 to 11 per cent. of protein. Last year the average price was about 10 per cent. higher.

Calf Meal, Meat Scrap and Poultry Foods.

One brand of calf meal, four of ground meat scrap and three of poultry food have been examined. Of these one of the meat samples is without guarantee and another is below guarantee in fat. One of the poultry foods also is low in fat.

In price the meats range from $42.50 to $52; the calf meal is sold for $70, and the poultry foods range from $30 to $35, substantially as last year.

FEEDS NOT REQUIRING GUARANTEE.

Wheat Products.

The wheat products examined this year include thirteen samples of bran and eleven samples of wheat feed, two of which consist of low-grade wheat, ground. These two are consequently of lower protein content than the usual wheat feed, and are omitted from the average. The wheat feed known as the "Jersey" is likewise omitted on account of its containing ground corn cob. This material was sold under a guarantee which was fulfilled; nevertheless, in the light of the general usage of the name, the branding of this material as a "wheat feed" is of the nature of a fraud upon an *unsuspecting* public buying this material as a straight wheat feed.

With these exceptions, these wheat products seem to be pure, although it must be said that the majority of the brans examined are not of the average quality observed last year. Two of them show traces of oats, which, however, is probably accidental. Another contains considerable chaff, rye and weed seeds.

A special examination of middlings, feeding flour and kindred materials was made this year, 139 samples having been analysed. The titles under which these materials were sold are variable, and affixed without any discernible relation to either appearance or analysis. They have, therefore, been grouped and averaged without strict regard to such titles, as will be noticed from the column in the tables,

in which they have been given. Even with this grouping the materials are somewhat variable. This seems to be due to a variability in the proportions of the different parts of the grain, which are allowed to go toward making up these by-products. Thus, ten samples of middlings and two of red dog flour were found to contain an abnormal amount of flour. One sample, No. 3,300, sold under guarantee as "Colonial" Middlings, contains considerable hominy meal; it furnishes the nutrients guaranteed, but, nevertheless, the use here of the term "middlings" is open to criticism.

The wheat products, as a whole, are from 9 to 10 per cent. cheaper this year than last.

Rye Products.

The foregoing remarks are applicable to the rye products also, of which fifteen samples have been examined. No real adulterations have been detected, but a great variability exists, due to certain samples being whole rye ground up, and others consisting to a greater or less degree of the bran, the middlings or of the flour.

The prices of the rye products this year are about 9 per cent. cheaper than at the last inspection.

Buckwheat Products.

Eleven samples of buckwheat bran and seven of buckwheat middlings have been examined. In these no other material than buckwheat has been found, but four (Nos. 3,334, 3,497, 3,529 and 3,516) contain excessive amounts (29 to 60 per cent.) of coarse buckwheat hulls, and four others show an abnormal amount of buckwheat flour, both departures from standard composition, and tending to lower the content of protein.

The buckwheat products average about $20 in price at this inspection, as compared with $22 at the last.

Barley Products.

One sample each of barley "feed" and barley "meal" have been examined. These were sold with a guarantee, but, under the law, are included in the present classification. The guarantees are correct in respect to protein, but the barley feed is deficient in fat. In fact, this sample contains the hulls of oats, which would indicate that it

was intended to be a feed mixture. If so, the use of the term "feed" in this instance is misleading. The barley meal corresponds in analysis with the sample of a year ago, and, in fact, came from the same dealer. It cost this year $22 per ton.

WHOLE GRAINS GROUND TOGETHER.

Corn and Oats.

The seventeen samples of "corn and oats" include twelve in which varying amounts of cob have been found, indicating that the entire ear of corn has been used; a few samples show sufficient oat hulls to indicate that "light" oats have been used, notably No. 3,408, of Wilkinson, Gaddis & Company; four contain wheaten material, No. 3,632, from H. Banker, containing considerable of either a feeding flour or a wheat middlings; two samples contain some straw, and one was moldy. The mold in this case, although barely discernible by the unaided senses, was sufficient to materially reduce the content of fat. The effect of the growth of mold upon the composition was described at length in Bulletin No. 160 and in the Annual Report of last year.

Horse Feeds from Whole Grains.

The twenty-seven samples of miscellaneous grains ground together are similar to the foregoing, except that an additional grain, usually rye, is added. All but one contain corn, and all but another contain oats. In a number of cases some cob is included with the corn, and in four cases the amount of hulls present would indicate the use of light oats.

Miscellaneous Materials.

Four samples of parts of the peanut plant have been examined. Two are peanut "bran," one is peanut "middlings," and the remaining one is peanut vine, dried and ground. These samples were not taken in the regular way, and were examined to ascertain their suitability as cattle feeds. One of the bran samples is apparently ground peanut shells; the other "bran" contains much less of the shells and the "middlings," while similar in appearance and content of protein and fat, has an unaccountably large amount of fibre. The peanut vine corresponds well to the hay of the legumes.

OIL CAKE MEALS.

Cottonseed Meal.

PRIME BRAND.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat Found.	Fat Guaranteed.
	American Cotton Oil Co., New York City.		%	%	%	%
3255	G. T. Freeman	Whippany	43.25	43.00	10.34	9.00
3372	Trenton Mills and Elevator Co	Trenton	42.25	43.00	9.22	9.00
3554	R. W. Smith	Elmer	46.99	43.00	10.42	9.00
	Average		44.16	43.00	9.99	9.C0

CANARY BRAND.

	R. W. Biggs & Co , Memphis, Tenn.					
3374	J. E. Stevenson Co	Trenton	44.71	43.00	8.91	9.00

OWL BRAND.

	F. W. Brode & Co., Memphis, Tenn.					
3157	Simmons & Martin	Sussex	44.63	43.00	8.73	9.00
3345	W. D. Rogers & Co	Moorestown	44.15	43.00	9.35	9.00
3493	S. L. Pancoast	Mullica Hill	44.64	43.00	10.43	9.C0
	Average		44.47	43.00	9.50	9.00

COFCO BRAND.

	Cotton Oil and Fibre Co., Norfolk, Va.					
3438	Sitley & Son	Camden	44.54	43.00	10.79	9.00
3467	Colkit & Thompson	Mount Holly	41.08	43.00	11.61	9.00
3459	Taylor Bros	Camden	44.22	43.00	11.37	9.00
3573	A. G. Johnson	Bridgeton	44.31	43.C0	12.C8	9.00
3654	Peterson & Smith	Woodstown	43.76	43.00	12.C9	9.00
	Average		43.58	43.00	11.59	9.00

DIXIE BRAND.

	Humphreys, Godwin & Co., Memphis, Tenn.					
3582	Mixner & Mickel	Bridgeton	44.50	43.00	12.95	9.00

NEW PROCESS LINSEED MEAL.

	American Linseed Co., Chicago, Ill.					
3093	A. N. Roe & Son	Branchville	37.25	38.00	3.37	1.00

OIL CAKE MEALS.

LINSEED MEAL.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	American Linseed Co., Chicago, Ill.		%	%	%	%
3062	Meyer & De Vogel	Paterson	33.25	32.00	7.36	5.00
3092	A. N Roe & Son	Branchville	31.72	32.00	6.64	5.00
3233	Jaqui & Co.	Morristown	34.74	32.00	13.73	5.00
3371	Trenton Mills and Elevator Co	Trenton	32.51	32.00	6.86	5.00
3462	Taylor Bros	Camden	31.91	32.00	6.60	5.00
	Average		32.83	32.00	8.24	5.00
	Chapin & Co., Philadelphia, Pa.					
3282	The Hildebrant Co	Elizabeth	37.66	36.00	7.04	7.00
	The Grove Linseed Oil Co., Philadelphia, Pa.					
3440	Sitley & Son	Camden	33.58	32.00	11.49	5.00
	Hunter Bros., St. Louis, Mo.					
3604	C. Cast	Egg Harbor City	36.74	34.00	8.04	6.50
3512	S L. Pancoast	Mullica Hill	37.66	34.00	8.85	6.50
	Average		37.20	34.00	8.45	6.50
	Metzger Seed and Oil Co., Toledo, O.					
3296	A. L. Cadmus	Plainfield	37.00	32.00	9.03	5.00
	Midland Linseed Oil Co., Minneapolis, Minn.					
3045	R. J. O'Brien & Bros. Co.	Passaic	36.81	32.50	6.05	5.50
3318	Mundy Bros	Bound Brook	33.67	32.50	8.77	5.50
	Average		35.24	32.50	7.41	5.50

CORN PRODUCTS.

GERM MEAL.

	The Atlas Cereal Mfg. Co., Fish House, N. J.					
3598	H. B. Haines	Mount Holly	15.66	11.53	39.31	34.48

CHICAGO GLUTEN MEAL.

	Glucose Sugar Ref. Co., Chicago, Ill.					
3442	Taylor Bros	Camden	35.21	38.00	2.86	3.30
358[illegible]	A. A. Boon & Son	Bridgeton	37.61	38.00	2.22	3.00
	Average		36.41	38.00	2.54	3.15

CORN PRODUCTS.

BUFFALO GLUTEN FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Glucose Sugar Ref. Co., Chicago, Ill.		%	%	%	%
3162	R. Harden	Hamburg	25.56	28.50	3.23	2.50
3347	W. D. Rogers & Co.	Moorestown	23.23	27.00	2.67	2.96
3348	Worman Mills	Frenchtown	27.87	27.00	2.82	2.96
3378	Stults Bros	Trenton	26.52	27.00	3.04	2.96
3441	Sitley & Son	Camden	26.31	28.00	3.06	3.30
3507	S. L. Pancoast	Mullica Hill	26.26	28.00	3.27	3.30
3509	Davis, Colson & Co.	Woodstown	26.07	27.00	3.72	2.96
3511	C. H Kirby	Medford	24.71	27.00	2.71	2.96
3540	T. S. Page & Co	Columbus	23.45	27.00	3.05	2.96
3379	A. S. Golden	Hopewell	27.69	27.00	4.22	2.96
3559	Hires & Co.	Quinton	27.14	27.00	3.06	2.96
3655	C. A. & T. P. Reed	Pennington	25.20	27.00	3.09	2.96
	Average		25.83	27.29	3.16	2.97

QUEEN GLUTEN FEEDS.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	National Starch Co., New York City.					
3022	Long Dock Mills and Elevator Co.	Jersey City	24.31	31.70	3.32	4.30
3388	Trenton Mills and Elevator Co	Trenton	27.27	27.10	2.09	3.20
3333	Ira Hill	Copper Hill	22.51	27.10	2.81	3.20
3444	Taylor Bros	Camden	25.50	27.10	2.32	3.20
3473	Rogers & French	Mount Holly	23.78	27.10	2.88	3.20
3587	Fithian & Pennell	Bridgeton	22.99	27.01	2.53	3.02
3564	A. G. Johnson	Bridgeton	25.34	26.90	2.23	3.50
	Average		24.53	27.72	2.60	3.37

GLOBE GLUTEN FEEDS.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	New York Glucose Co., New York City.					
3079	J. English	Paterson	29.81	27.50	2.15	3.38
3057	Thos. Eggert & Co.	Perth Amboy	27.50	27.50	4.48	3.38
3182	C. T. Mott & Co	Vernon	26.38	27.00	3.18	3.38
3248	Jaqui & Co	Morristown	28.56	27.50	4.21	3.38
3319	P. J. Staats	Bound Brook	24.86	28.00	2.83	3.38
3336	B Hoffman	Ringoes	27.43	27.50	3.25	3.38
3424	Wyckoff's Mills	Turkey	24.71	27.50	2.47	3.38
3547	Townsend & Ware	Columbus	22.99	27.50	2.99	3.38
3565	F. D. Duffield	Elmer	26.86	27.00	3.06	3.38
3566	Mixner & Mickel	Bridgeton	24.14	27.50	2.36	3.38
	Average		26.32	27.45	3.10	3.38

MISCELLANEOUS GLUTEN FEEDS.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
3127	Van Winkle Grain and Feed Co.	Paterson	10.31	13.00	4.49	....
3216	J. Gardner.	Dover	22.72	....	3.10	....

CORN PRODUCTS.

HOMINY MEAL.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found	Fat. Guaranteed.
	American Hominy Co., Chicago, Ill.		%	%	%	%
3091	A. N. Roe & Son	Branchville	12.06	11.40	9.56	9.15
3260	G. F. Freeman	Whippany	11.72	10.24	9.29	7.72
3249	Jaqui & Co	Morristown	12.19	10.24	9.62	7.72
3066	M. J. Phelan	Paterson	10.08	10.24	5.56	7.72
3059	Perth Amboy Grain Co	Perth Amboy	11.30	10.24	9.76	7.72
3635	C. W. Russell	New Brunswick	11.78	12.85	9.16	8.52
	Average		11.52	10.87	8.83	8.09
	Bishopp Hominy Co., Sheldon, Ill.					
3094	Van Winkle Grain and Feed Co	Paterson	10.74	10.13	7.94	7.60
	Chapin & Co., Philadelphia, Pa.					
3011	Holley & Smith	Hackensack	11.63	11.00	9.92	8.00
3:94	G. O. Young	Tranquility	10.44	11.00	7.54	8 00
3258	A. Cyphers	Newark	10.24	11.00	8.40	8.00
	Average		10.77	11.00	8.62	8.00
	Cumberland Mills, Nashville, Tenn.					
3537	T. S. Page & Co	Columbus	11.73	....	9.42	....
	Fish & Co., New York City.					
3031	J. & H. Steinberg	Passaic	11.56	5.00	9.30	3.00
	Howell & Webster, Middletown, N. Y.					
3141	Lawrence & Harden	Sussex	11.59	....	9.75	....
	Hunter Bros., St. Louis, Mo.					
3003	H. Looker	Boonton	12.75	11.02	10.47	7.70
3483	Rogers & French	Mount Holly	11.63	10.68	11.16	9.76
	Average		12.19	10.85	10.82	8.73
	Miner-Hilliard Mill. Co., Wilkesbarre, Pa.					
3105	Carpenter & Quince	Baleville	12.01	10.87	8.80	8.46
	Suffern, Hunt & Co., Decatur, Ill.					
3065	J. English	Paterson	12.19	11.02	9.83	7.70
	The Toledo Elevator Co., Toledo, O.					
3226	Pursel Milling and Coal Co	Phillipsburg	10.88	12.60	8.09	8.57
	S. W. Weidler Co.					
3133	Hart & Iliff	Newton	11.13	10.00	8.86	7.00
	M. M. Wright & Co., Danville, Ill.					
3096	McDonalds & Lance	Branchville	11.50	10.93	9.88	8.00
	Source Unknown.					
3076	Meyer & De Vogel	Paterson	11.84	....	9.23	....
	Average of all brands		11.47	10.58	9.12	7.80

CORN PRODUCTS.

MAIZELINE FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	American Hominy Co., Chicago, Ill.		%	%	%	%	%
3463	Sitley & Son	Camden	11.44	10.42	7.88	9.03	5.29
3551	E. L Davis	Wrightsville	8.77	10.42	4.41	9.03	10.32

CEREALINE FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	American Hominy Co., Chicago, Ill.						
3099	R. V. Northrup	Augusta	13.00	13.99	9.87	9.12	4.67
3159	R. Harden	Hamburg	12.66	13.99	11.82	9.12	3.75
3346	W. D. Rogers & Co.	Moorestown	10.08	....	6.55	....	5.13
3465	J. S. Collins & Son	Moorestown	10.50	7.88	8.19	5.99	6.50
3538	Est. J. W. Biddle	Columbus	11.13	7.88	6.64	5.99	7.22
3539	Townsend & Ware	Columbus	12.19	....	10.59	....	3.48
	Average		11.59	....	8.94	....	5.13

FANCY CORN BRAN.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Glucose Sugar Ref. Co., Chicago, Ill.						
3113	R. V. Northrup	Augusta	12.62	14.00	2.66	4.00	12.86
3101	Van Winkle Grain and Feed Co.	Paterson	10.38	13.36	4.26	3.44	13.81
3161	R. Harden	Hamburg	11.58	14.00	2.68	3.50	12.61
3506	C. C. Dempsey	Gloucester	12.66	14.00	2.96	4.00	12.51
3560	J. K. Waddington	Salem	13.23	14.00	2.54	4.00	12.16
3490	C. H. Kirby	Medford	13.11	14.00	2.86	4.00	12.67
	Average		12.30	13.89	2.99	3.82	12.77

CORN BRAN, OR SUGAR FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Atlas Cereal Mfg. Co., Fish House, N. J.						
3599	(*Wet.) H. B. Haines	Mount Holly	5.45	....	3.28	....	7.42
3492	(Dry.) C. C. Dempsey	Gloucester	10.60	8.14	5.09	5.57	8.82
	M. G. Rankin & Co., Milwaukee, Wis.						
3457	Taylor Bros	Camden	9.94	9.00	2.80	3.00	16.99
	C. W. Wagar & Co., Philadelphia, Pa.						
3649	Hopkins & Lippincott	Moorestown	12.49	11.75	4.61	5.00	15.02

* Contains 40 per cent. moisture.

DISTILLERY AND BREWERY PRODUCTS.

ATLAS GLUTEN MEAL.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Atlas Feed and Milling Co., Peoria, Ill.		%	%	%	%
3150	R. Harden	Hamburg	37.06	35.00	13.76	11.50
3373	W. D. Rogers & Co.	Moorestown	35.01	36.00	17.36	11.50
3653	Taylor Bros.	Camden	32.90	36.50	15.88	13.40
	Average		34.99	35.83	15.67	12.13

AJAX FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Chapin & Co., Philadelphia, Pa.					
3640	Mr. Porter	New Brunswick	30.41	34.0	13.34	12.00

GRANO GLUTEN FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Hottelet & Co., Milwaukee, Wis.					
3561	R. W. Smith	Elmer	22.99	20.00	8.56	8.00

DISTILLERS' GRAINS.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	Worman Mills, Frenchtown, N. J.					
3439	B. Devitt	Frenchtown	18.99	18.08	9.09	6.50

MALT SPROUTS.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	American Malting Co., Chicago, Ill.					
3223	J. S. Hance	Hackettstown	25.57	26.79	1.45	1.44
3376	J. H. Ashton	Trenton	27.46	26.79	2.69	1.44
	Average		26.52	26.79	2.07	1.44
	M. F. Baringer, Philadelphia, Pa.					
3536	Townsend & Ware	Columbus	23.18	26.00	5.38	1.91
	Buerger Malting Co., Mayville, Wis.					
3375	J. E. Stevenson Co.	Trenton	28.84	25.00	3.07	2.00
	Chapin & Co., Philadelphia, Pa.					
3285	C F. French	Plainfield	27.78	25.00	1.95	2.00
	R. R. Cordner, Middletown, N. J.					
3136	Hart & Iliff	Newton	22.98	....	1.72	....

DISTILLERY AND BREWERY PRODUCTS.

MALT SPROUTS—Continued.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	C. G. Curtiss Co., Buffalo, N. Y.		%	%	%	%
3121	(Kiln), A. N. Roe & Son	Branchville	27.38	23.72	1.19	1.30
3122	(Mill), A. N. Roe & Son	Branchville	24.19	25.29	1.70	1.42
	F. W. Goeke & Co., St. Louis, Mo.					
3215	J. P. Hoffman	Hackettstown	17.56	....	2.96	....
3176	W. H. Ingersoll	Hamburg	20.08	....	2.25	....
	Average		18.82	....	2.61	....
	Hottelet & Co., Milwaukee, Wis.					
3167	R. Harden	Hamburg	24.50	26.50	2.89	3.40
3656	C. A. &. T. P. Reed	Pennington	25.39	26.50	1.41	3.40
	Average		24.95	26.50	2.15	3.40
	P. C. Kamm & Co., Milwaukee, Wis.					
3002	H. Looker	Boonton	27.50	26.25	2.25	1.01
3195	A. B. Albert	Danville	24.94	26.25	2.75	1.01
3544	Est. J. W. Biddle	Columbus	25.85	26.25	3.86	1.01
	Average		26.10	26.25	2.95	1.01
	J. D. Macky, Philadelphia, Pa.					
3072	J. English	Paterson	*20.19	....	2.01	....
	Meurer, Deutsch & Sickert Co., Milwaukee, Wis.					
3265	E. H Ball	Troy Hills	29.26	....	1.70	....
	E. P. Mueller, Milwaukee, Wis.					
3179	Simmons & Martin	Sussex	25.75	26.25	2.39	1.91
3387	A. S. Golden	Hopewell	26.71	26.25	1.91	1.91
3203	G. O. Young	Tranquility	27.57	24.00	1.36	2.00
	Average		26.68	25.50	1.89	1.94
	Penn Grains and Feed Co., Philadelphia, Pa.					
3474	Rogers & French	Mount Holly	29.21	28.76	3.18	1.53
	Henry Rang & Son, Milwaukee, Wis.					
3461	Taylor Bros	Camden	28.34	23.00	1.56	2.95
	John Rankin & Co., Chicago, Ill.					
3098	R. V. Northrup	Augusta	26.53	26.25	2.48	1.91
3132	Lawrence & Harden	Sussex	26.08	26.25	2.13	1.91
	Average		26.31	26.25	2.31	1.91

* Contains 26.02 per cent. fiber.

DISTILLERY AND BREWERY PRODUCTS.

MALT SPROUTS—Continued.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed
	M. G. Rankin & Co., Milwaukee, Wis.		%	%	%	%
3106	Carpenter & Quince	Baleville	29.40	25.00	1.42	2.00
3390	Blackwell & Hill	Hopewell	27.64	25.00	1.16	2.00
3005	H. Looker	Boonton	21.57	25.00	2.93	2.00
3445	Sitley & Son	Camden	28.16	25.19	1.85	0.67
	Average		26.69	25.05	1.84	1.67
	T. H. Topping, Clyde, N. Y.					
3071	J. A. Lydecker	Paterson	26.31	....	2.78	....
3114	P. O'Blenis	Paterson	26.31	....	2.80	....
	Average		26.31	....	2.79	....
	D. R. Worman, Philadelphia, Pa.					
3342	B. Hoffman	Ringoes	24.70	....	2.08	....
	Source Unknown.					
3074	Meyer & De Vogel	Paterson	18.23	....	1.73	....
3427	E. C. Norton	Hightstown	25.94	....	3.85	....
	Average of all brands		25.48	....	2.33	....

DRIED BREWERS' GRAINS.

	Anheuser-Busch Brewing Asso., St. Louis, Mo.					
3085	Hopkins & Williams Co	Newton	23.82	25.81	7.31	7.20
3207	J. P. Hoffman	Hackettstown	23.82	25.81	7.02	7.20
	Average		23.82	25.81	7.17	7.20
	Atlantic Export Co., Brooklyn, N. Y.					
3535	Est. J. W. Biddle	Columbus	34.04	22.24	7.37	7.01
	Howell & Webster, Middletown, N. Y.					
3165	Simmons & Martin	Sussex	30.00	23.00	8.87	....
	P. C. Kamm & Co., Milwaukee, Wis.					
3545	Townsend & Ware	Columbus	22.58	23.85	6.20	6.13
	J. C. Klauder Est., Philadelphia, Pa.					
3514	C. H. Kirby	Medford	22.85	23.24	7.32	7.64
3552	M. E. Lamb	New Egypt	21.89	23.24	6.42	7.64
3643	Sharpless & Co	Camden	30.60	23.24	7.94	7.64
	Average		25.11	23.24	7.23	7.64

DISTILLERY AND BREWERY PRODUCTS.

DRIED BREWERS' GRAINS—Continued.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.
	G. C. Krueger Drying Co., Newark, N. J.		%	%	%	%
3294	C. F. French	Plainfield	27.25	23.71	7.75	7.80
3317	P. J. Staats	Bound Brook	30.29	23.71	8.27	7.80
	Average		28.77	23.71	8.01	7.80
	McKeown & Spence, New York City.					
3660	D. D. Solomon	West Freehold	26.13	22.24	8.47	7.01
	E. P. Mueller, Milwaukee, Wis.					
3247	Jaqui & Co.	Morristown	27.19	23.85	7.14	6.13
3385	Trenton Mills and Elevator Co.	Trenton	34.04	23.85	7.56	6.13
3357	W. D. Rogers & Co	Moorestown	25.60	31.36	6.41	6.34
3472	Colkitt & Thompson	Mount Holly	32.40	25.00	8.02	7.00
	Average		29.81	26.02	7.28	6.40
	Penn Grains and Feed Co., Philadelphia, Pa.					
3475	Rogers & French	Mount Holly	28.33	23.30	6.49	4.97
	M. G. Rankin & Co., Milwaukee, Wis.					
3119	Carpenter & Quince	Baleville	28.38	25.00	6.12	7.00
3205	A. B. Albert	Danville	26.56	25.00	6.68	7.00
3389	J. E. Stevenson Co.	Trenton	28.98	25.00	6.86	7.00
3460	Taylor Bros	Camden	27.28	21.94	7.06	7.71
3574	C. Kelty	Salem	25.94	22.59	7.91	7.90
	Average		27.42	23.91	6.93	7.32
	D. R. Worman, Philadelphia, Pa.					
3575	Hires & Co.	Quinton	25.16	22.00	7.15	7.00
	Average of all brands		27.41		7.29	

DRIED BREWERS' GRAINS AND MOLASSES.

	E. P. Mueller, Milwaukee, Wis.					
3659	Taylor Bros	Camden	17.69	20.05	2.57	2.26

FEED MIXTURES.

CORN, OATS AND BARLEY FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	American Cereal Co., Chicago, Ill.		%	%	%	%	%
3254	G. T. Freeman	Whippany	12.99	13.00	5.80	5.00	8.62
3277	H. Nischwitz & Co.	Plainfield	13.23	13.00	5.51	5.00	8.42
	Average		13.11	13.00	5.66	5.00	8.52

COTTONSEED FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	L. I. Logan & Co., Philadelphia, Pa.						
3428	E. C. Norton	Hightstown	9.00	12.43	2.37	6.17	37.78

FEED MIXTURES.

GUARANTEED LOCAL FEED MIXTURES.

Station number.	Manufacturer, Jobber or Dealer.	Ingredients.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
			%	%	%	%	%
3191	Belvidere Flour Mill Co., Belvidere, N. J.	....	12.00	9.80	3.03	2.40	3.86
3067	Joseph English, Paterson, N. J.	Oats, feeding flour, hominy and rice hulls	12.56	11.13	7.27	7.01	9.70
3168	Reeve Harden, Hamburg, N. J. (No. 1.)	....	13.13	10.00	7.67	5.00	4.62
3171	W. H. Ingersoll, Hamburg, N. J. (Hercules.)	Oats, wheat and hominy	12.19	10.00	5.98	5.00	4.67
3172	W. H. Ingersoll, Hamburg, N. J. (Utility)	Oats, wheat, buckwheat middlings	14.25	9.00	7.10	4.00	7.22
3515	C. H. Kirby, Medford, N. J. (Dairy Feed)	....	14.03	12.48	3.75	3.24	9.21
3196	G. K. & O. H. McMurtrie, Belvidere, N. J.	....	11.93	10.00	3.24	3.00	2.40
3215	Miller & Mott, Rockaway, N. J.	Hominy, red dog, Vim oats	14.63	12.00	6.38	5.00	7.09
3458	Taylor Bros, Camden, N. J. (No. 2 Dairy Feed)	....	12.76	12.00	3.08	3.50	6.02
3305	Wilkinson, Gaddis & Co., Newark, N. J.	Corn, Marsden Feeds, Nos. 1 and 2	9.57	8.90	3.44	3.50	2.81
	Average	....	12.71	10.53	5.09	4.17	5.76

3191 contained oats, wheat, bran and corn.
3168 contained corn, rye, oats and wheat.
3515 contained wheat, bran, oats and cob meal.
3196 contained corn, oats, wheat and possibly buckwheat.
3458 contained corn, oats, wheat and buckwheat.
3305 contained corn, oats and barley (no Marsden feed found).

FEED MIXTURES.

UNGUARANTEED LOCAL FEED MIXTURES.

Station number.	Manufacturer, Jobber or Dealer.	Ingredients.	Protein. Found.	Protein. Calculated.	Fat. Found.	Fat. Calculated.	Fiber.
			%	%	%	%	%
3050	Campbell, Morrell & Co., Passaic, N. J...	Hominy, middlings cornmeal, oats, gluten feed.	12.94	12.50	5.64	5.40	5.53
3240	James Gardner, Dover, N. J...........	Middlings, Royal oats, cobmeal	13.54	11.30	4.05	3.10	7.54
3169	Reeve Harden, Hamburg, N. J. (No. 2.)...	Cerealine, red dog, Royal oats, oat chop, wheat feed.	12.44	11.10	7.02	6.00	7.51
3316	[1] Higgins & Bro., Three Bridges, N. J..	Corn, oats, rye, wheat	10.20	9.90	3.90	3.70	2.73
3293	The Hildebrant Co., Elizabeth, N. J...	Cornmeal, hominy, Boss corn and oats, Vim oats.....	9.56	9.20	4.42	4.80	6.31
3243	Jaqui & Co., Morristown, N. J. (No. 2.)...	Middlings, hominy, Royal oats..........	12.34	12.10	6.59	5.20	10.63
3078	Meyer & De Vogel, Paterson, N. J...	Hominy, brown middlings, Vim oats....................	12.25	11.90	8.12	7.40	6.48
3227	Pursel Mill and Coal Co., Phillipsburg, N. J ..	Corn, hominy, rye bran, Vim oats...	11.25	11.00	4.87	5.10	4.74
3046	[2] J. C. Smith & Wallace Co., Newark, N. J. (Company Feed)...	Hominy, barley feed, Royal oats...	13.63	11.60	6.37	6.30	5.87
3126	Van Winkle Grain and Feed Co., Paterson, N. J. (No. 2)...	Hominy, Vim oats, rye, gluten feed...	11.54	11.20	5.52	4.60	7.01
3230	J. S. Wiseburn, New Hampton, N. J...	Corn ears, rye, G. W. dairy feed......	8.53	8.90	3.05	2.50	6.51
3367	Worman Mills, Frenchtown, N. J..	Corn, rye, dried brewers' grains.[3]	11.31	14.40	2.38	4.30	2.33
	Average...........	....	11.63	11.26	5.16	4.87	6.10

[1] Stock of R. F. Hohenstein, Westfield.

[2] Stock of John Post, Passaic.

[3] Oats were found in place of brewers' grains.

FEED MIXTURES.

Oat Feeds and Corn and Oat Feeds.

QUAKER DAIRY FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	American Cereal Co., Chicago, Ill.		%	%	%	%	%
3232	Jaqui & Co	Morristown	16.08	14.00	3.93	3.50	14.39
3278	G. B. Benedict	Elizabeth	15.29	14.00	3.26	3.50	13.34
3344	W. F. Wood	Belle Meade	13.36	14.00	3.08	3.50	17.63
3370	Stults Bros	Trenton	15.28	14.00	4.30	3.50	14.75
	Average		15.00	14.00	3.64	3.50	15.03

VICTOR CORN AND OAT FEED.

	American Cereal Co., Chicago, Ill.						
3009	Miller & Bertholf	Jersey City	9.63	9.00	4.62	4.00	10.31
3086	Hopkins & Williams Co	Newton	9.66	9.00	3.92	4.00	8.14
3231	Miller & Mott	Rockaway	9.28	9.00	4.67	4.00	8.63
3437	A. K. Ashby	Burlington	9.94	9.00	4.91	4.00	9.79
3553	J. K. Waddington	Salem	10.51	9.00	5.36	4.00	8.79
	Average		9.80	9.00	4.68	4.00	9.13

VIM OAT FEED.

	American Cereal Co., Chicago, Ill.						
3131	Hopkins & Williams Co	Newton	7.88	7.50	3.07	2.75	23.94
3063	Meyer & De Vogel	Paterson	8.72	7.50	3.30	2.75	23.06
3208	Pursel Milling and Coal Co	Phillipsburg	8.34	7.50	3.08	2.75	23.90
3534	E. L. Davis	Wrightsville	7.97	7.50	3.40	2.75	24.16
	Average		8.23	7.50	3.22	2.75	23.77

STOCK FEED.

	Buffalo Cereal Co., Buffalo, N. Y.						
3281	Van Zant & Voorhees	Plainfield	9.13	10.00	4.56	5.00	17.60

FEED MIXTURES.

Oat Feeds and Corn and Oat Feeds—Continued.

EXCELSIOR FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	F. A. Champlin & Co., Newark, N. J.		%	%	%	%	%
3137	Hart & Iliff	Newton	10.94	10.06	5.53	4.14	4.66

DIAMOND CORN AND OATS.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Diamond Mills, Buffalo, N. Y.						
3031	Passaic Feed Co	Passaic	9.69	9.41	5.80	4.78	8.94

BOSS CORN AND OATS FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Great Western Cereal Co., Chicago, Ill.						
3013	Miller & Bertholf	Jersey City	9.63	7.94	5.62	4.18	12.74
3286	The Hildebrant Co	Elizabeth	8.06	8.37	3.37	3.65	12.51
3633	C. W. Russell	New Brunswick	8.49	7.94	3.15	4.18	13.21
	Average		8.73	8.08	4.05	4.00	12.82

DAIRY FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Great Western Cereal Co., Chicago, Ill.						
3218	J. S. Wiseburn	New Hampton	11.31	12.25	3.25	3.20	19.46
3237	Jaqui & Co	Morristown	10.08	12.25	3.35	3.20	22.66
	Average		10.70	12.25	2.96	3.20	21.06

ROYAL OAT FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Great Western Cereal Co., Chicago, Ill.						
3068	J. English	Paterson	6.31	7.53	2.03	2.65	24.50
3238	J. Gardner	Dover	5.50	8.25	2.24	4.14	28.35
3164	Simmons & Martin	Sussex	9.80	7.53	3.56	2.65	20.16
3542	T. S. Page & Co	Columbus	8.44	7.53	3.52	2.65	22.98
	Average		7.51	7.71	2.84	3.02	24.00

FEED MIXTURES.

Oat Feeds and Corn and Oat Feeds—Continued.

H. O. DAIRY FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	The H. O. Co., Buffalo, N. Y.		%	%	%	%	%
3264	A. Cyphers	Newark	19.04	18.00	4.48	4.50	11.84
3290	G. B. Benedict	Elizabeth	18.10	18.00	4.75	4.50	11.42
	Average		18.57	18.00	4.62	4.50	11.63

H. O. HORSE FEED.

	The H. O. Co., Buffalo, N. Y.						
3263	A. Cyphers	Newark	13.27	12.00	4.88	4.50	10.61
3288	The Hildebrant Co	Elizabeth	13.13	12.00	5.13	4.50	8.99
3470	Rogers & French	Mount Holly	14.71	12.00	2.74	4.50	8.85
	Average		13.70	12.00	4.25	4.50	9.48

HUNTER'S OAT FEED.

	Hunter Bros., St. Louis, Mo.						
3456	Taylor Bros	Camden	7.69	7.00	3.05	2.75	23.62

MONARCH CHOP FEED.

	Husted Mill. and Elev. Co., Buffalo, N. Y.						
3143	Lawrence & Harden	Sussex	10.50	10.40	4.99	3.27	6.56

STAR CHOP.

	Miner-Hilliard Mill. Co., Wilkesbarre, Pa.						
3298	H. Nischwitz & Co	Plainfield	8.53	9.79	3.70	6.70	11.78

NORTHERN MILLING CO.'S OAT FEED.

	Northern Milling Co., Chicago, Ill.						
3562	L. J. Holladay	Harmersville	7.94	5.50	2.82	4.00	22.96

YELLOW FEED.

	J. C. Smith & Wallace Co., Newark, N. J.						
3271	J. C. Smith & Wallace Co	Newark	10.04	....	3.43	....	2.07

CALF MEAL, GROUND MEAT AND POULTRY FEEDS.

BLATCHFORD'S CALF MEAL.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	J. W. Barwell, Waukegan, Ill.		%	%	%	%	%
3158	R. Harden	Hamburg	25.38	26.00	4.90	5.00	....

ANIMAL MEAL AND GROUND MEAT.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Bowker Fertilizer Co., New York City.						
3615	S. Anderson	Hammonton	31.76	30.00	9.35	5.00	....
	Darling & Co., Chicago, Ill.						
3109	A. N. Roe & Son	Branchville	59.94	60.19	10.41	14.43	....
	M. L. Shoemaker & Co., Philadelphia, Pa.						
3629	S. Anderson	Hammonton	56.03	34.00	12.46	5.00	....
	E. H. Shuster & Co., Woodbury, N. J.						
3525	C. C. Dempsey	Gloucester	47.46	....	18.77	....	....

AMERICAN POULTRY FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	American Cereal Co., Chicago, Ill.						
3089	P. O'Blenis	Paterson	14.38	14.00	6.73	4.50	4.12

H. O. POULTRY FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	The H. O. Co., Buffalo, N. Y.						
3351	J. S. Middleton	Camden	16.51	17.00	5.39	5.50	4.35
3469	Rogers & French	Mount Holly	16.32	17.00	5.06	5.50	5.13
	Average	....	16.42	17.00	5.23	5.50	4.74

H. AND L. POULTRY FEED.

Station number.	Manufacturer or Jobber and Dealer.	Place of Sampling.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Fiber.
	Hopkins & Lippincott, Moorestown, N. J.						
3642	Hopkins & Lippincott	Moorestown	17.42	18.00	7.50	9.00	9.30

WHEAT.

WINTER WHEAT BRAN.

Station number.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
			%	%	%
3577	M. F. Baringer, Philadelphia, Pa	Newport	17.35	4.20	8.87
3491	M. F. Baringer, Philadelphia, Pa	Allentown	17.63	4.80	7.08
3209	Burk Grain and Elevator Co., St. Louis, Mo	Hackettstown	17.38	4.25	7.76
3504	H. A. Ford, Allentown, N. J.	Allentown	*13.36	*3.56	*8.66
3017	Hecker-Jones-Jewell Milling Co., N. Y. City	Jersey City	15.80	4.90	8.82
3583	Hunter Bros., St. Louis, Mo	Port Norris	15.37	4.13	9.37
3521	Quaker City Milling Co., Philadelphia, Pa	Westville	15.16	4.66	7.51
3228	Simpson, Hendee & Co., N. Y. City	Phillipsburg	17.35	4.32	7.03
3051	David Watson, Tenafly, N. J	New Milford	15.14	4.28	7.57
3576	D. R. Worman, Philadelphia, Pa	Quinton	17.51	4.35	8.49
	Average		16.52	4.43	8.06

SPRING WHEAT BRAN.

3602	W. S. Ankeny & Co., Minneapolis, Minn	Egg Harbor City	17.54	5.64	9.25
3329	Hancock & Co., Philadelphia, Pa	Flemington	16.56	5.54	11.42
3268	Pillsbury Flour Co., Minneapolis, Minn	Newark	14.86	4.98	8.96
	Average		16.32	5.39	9.88

*Not included in the average.

WHEAT FEED.

Station number.	TITLE.	MANUFACTURER, JOBBER OR DEALER.	PLACE OF SAMPLING.	Protein.	Fat.	Fiber.
				%	%	%
3188	Buckeye	American Cereal Co., Chicago, Ill.	Tranquility	16.88	4.25	....
3630	Buckeye	American Cereal Co., Chicago, Ill.	New Brunswick	16.49	4.30	....
3324	Bluebell	American Cereal Co., Chicago, Ill.	Clinton	17.67	4.53	....
3103	Mixed Feed	M. F. Baringer, Philadelphia, Pa.	Baleville	17.63	4.48	....
3156	Mixed Feed	Blish Milling Co., Seymour, Ind.	Vernon	17.56	4.74	....
3178	Boston	Duluth Superior Milling Co., Duluth, Minn.	Sussex	16.81	5.40	....
3419	....	Chas. E. Hall, Turkey, N. J.	Turkey	*10.98	*2.09	2.03
3543	Jersey	Kentucky Milling Co., Henderson, Ky.	Columbus	*13.98	*3.40	13.20
3549	Mixed Feed	Simpson, Hendee & Co., New York City	Columbus	15.94	4.64	....
3399	....	Wm. N. Stewart, Englishtown	Englishtown	*10.08	*2.01	1.94
3185	Mixed Feed	Washington Flour Mill Co., Washington, Mo.	Hamburg	17.38	4.71	....
		Average	....	17.05	4.63	....

* Not included in the average.

WHEAT.

FEEDING FLOUR.

Station number.	Title.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.
				%	%
3130	Red Dog	American Cereal Co , Chicago, Ill	Newton	20.19	5.19
3393	Red Dog	W. S. Ankeny & Co., Minneapolis, Minn.	Red Bank	20.51	5.49
3151	Low Grade	M. F. Barringer, Philadelphia, Pa.	Hamburg	*15.76	3.32
3134	Low Grade	Cataract City Milling Co., Niagara Falls, N. Y.	Newton	*16.25	3.26
3234	Red Dog	Chapin & Co., Philadelphia, Pa	Rockaway	20.06	6.01
3326	Red Dog	G. C. Christian, Minneapolis, Minn	Clinton	21.24	5.95
3283	Red Dog	L G. Dey, Newark N. J.	Newark	20.25	6.02
3235	Red Dog	Duluth Superior Milling Co., Duluth, Minn	Dover	20.00	5.50
3104	Red Dog	Empire Grain and Elevator Co., Bing hamton, N. Y.	Baleville	21.38	6.40
3295	Red Dog	A. F. Lane, New York City	Elizabeth	19.20	5.78
3041	Red Dog	Long Dock Mills and Elevator Co., Jersey City, N. J.	Passaic	18.94	4.84
3145	White Middlings	Montevideo Roller Mills, Montevideo Minn	Dover	16.68	2.89
3619	Red Dog	New Prague Flouring Mill Co , Minnesota	Hammonton	19.39	4.37
3621	Red Dog, XXX Comet	Northwestern Consolidated Milling Co., Minneapolis, Minn	Erma	18.46	5.09
3204	Red Dog	Paine Bros. Co , Milwaukee, Wis.	Tranquility	21.00	5.92
3320	Daisy Red Dog	Pilsbury Flour Co , Minneapolis, Minn	Bound Brook	20.39	5.86
3476	Feeding Flour	Jas. Quirk Milling Co., Waterville, Minn.	Mount Holly	17.58	4.43
3478	Red Dog	Sitley & Son, Camden, N. J	Mount Holly	19.69	5.31
3007	Red Dog	J. C. Smith & Wallace Co., Newark, N. J.	Boonton	19.23	4.22
3480	Feeding Flour	Taylor Bros., Camden, N. J	Mount Holly	19.41	3.56
3273	Fancy White Middlings	Charles Thompson, Newark, N. J.	Madison	20.63	5.46
3023	White Middlings	P. H. Van Wagoner & Co , New York City	Hackensack	19.41	5.91
3341	Adrian	Washburn-Crosby Co , Minneapolis, Minn	Ringoes	17.35	4.88
3147	Red Dog	Wilkinson, Gadddis & Co., Newark, N. J.	Andover	19.41	5.33
		Average		19.27	5.20

*Not included in the average.

WHEAT.

WHITE MIDDLINGS.

Station number.	Title.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
				%	%	%
3053	White	W. N. Adair & Co., Raritan, N. J	East Millstone	15.85	3.93	2.42
3310	Shorts	W. N. Adair & Co., Raritan, N. J	Westfield	16.18	4.35	2.84
3189	Fancy White	W. S. Ankeny & Co, Minneapolis Minn	Tranquility	17.88	4.96	4.06
3603	No. 1 White	W. S. Ankeny & Co., Minneapolis, Minn	Egg Harbor City,	17.59	5.18	4.25
3052	White	P. E. Apgar, Weston, N. J	Weston	15.44	3.53	1.56
3416	White	Amos K. Ashby, Burlington, N. J	Burlington	14.96	4.75	1.08
3001	Shorts	Dwight M. Baldwin, Jr., Minneapolis, Minn	Boonton	18.19	5.03	4.74
3614	Middlings	Sam'l Bell & Son, Philadelphia, Pa	Hammonton	15.23	4.33	3.86
3192	White	Belvidere Flouring Mill Co., Belvidere, N. J	Belvidere	13.81	3.28	2.29
3210	White	Burk Grain and Elevator Co., St. Louis, Mo	Hackettstown	13.81	2.69	2.79
3135	Niagara White	Cataract City Milling Co., Niagara Falls, N. Y	Newton	16.81	5.35	5.49
3501	No. 1 White	Eastern Milling and Expt. Co., Philadelphia, Pa	Woodbury	17.07	5.86	5.17
3313	White	Flemington Milling Co., Flemington, N. J.	Westfield	15.91	4.60	2.91
3327	Shorts	Flemington Milling Co., Flemington, N. J.	Flemington	17.39	5.66	3.32
3502	Fancy White	H. A. Ford, Allentown, N. J	Allentown	14.91	4.47	2.29
3019	2d Grade	Holly & Smith, Hackensack, N. J	Hackensack	20.41	6.08	7.08
3069	White	Howell & Webster, Middletown, N. Y	Paterson	19.88	4.78	3.66
3584	No. 2 Fancy White	Hunter Bros., St. Louis, Mo	Port Norris	17.59	5.28	3.50
3381	White	E. C. Hutchinson Milling Co., Trenton, N. J	Trenton	15.48	3.94	2.93
3173	White Mill	W. H. Ingersoll, Hamburg, N. J	Hamburg	15.42	3.27	2.16
3421	Winter	Elmer E. Kulp, Philadelphia, Pa	Burlington	17.68	4.96	2.86
3044	Winter	John C. Liken & Co., Sebewaing, Mich	Harrington	16.00	5.45	3.91
3657	White	L J. Logan & Co, Philadelphia, Pa	Pennington	17.82	5.11	3.00
3116	Winter	Chas. R. Lull, Milwaukee, Wis	Paterson	18.69	4.39	4.14
3198	White	G. K. & O. H. McMurtrie, Belvidere, N. J	Belvidere	14.56	3.88	1.95
3618	Winter	Milbourne Mills Co., Philadelphia, Pa	Hammonton	17.17	6.35	3.64

WHEAT.

WHITE MIDDLINGS—Continued.

Station number.	Title.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
				%	%	%
3180	White	C. T. Mott & Co., Vernon, N. J.	Vernon	15.79	3.79	2.11
3429	Shorts	E. C. Norton, Hightstown, N. J.	Hightstown	14.19	3.81	1.75
3591	No. 2 White	Quaker City Milling Co, Philadelphia, Pa.	Bridgeton	16.82	5.21	3.74
3624	White	Quaker City Milling Co., Philadelphia, Pa.	Hammonton	13.96	3.66	2.54
3397	White	M. G. Rankin & Co., Milwaukee, Wis.	Englishtown	19.04	4.50	2.03
3340	Shorts	A. Rockafellow, Flemington, N. J.	Flemington	15.80	4.37	1.21
3644	No. 2 Fancy White	Sharpless & Bro., Camden, N. J.	Camden	17.96	4.07	2.84
3645	No. 1 White	Sharpless & Bro., Camden, N. J.	Camden	18.69	4.92	4.61
3646	No. 2 White	Sharpless & Bro., Camden, N. J.	Camden	18.70	6.24	5.87
3596	No. 2 Fancy White	Sheffield Milling Co., Faribault, Minn.	Vineland	17.83	5.21	4.66
3026	Winter	Shelby Milling Co, Shelby, O.	Harrington	17.06	4.38	4.07
3448	No. 2 Fancy White	Sitley & Son, Camden, N. J.	Camden	16.88	5.26	3.80
3449	No. 1 White	Sitley & Son, Camden, N. J.	Camden	17.35	5.65	3.79
3450	No. 2 White	Sitley & Son, Camden, N. J.	Camden	17.44	4.08	3.71
3430	Shorts	Sitley & Son, Camden, N. J.	Manasquan	17.35	4.37	3.01
3401	Shorts	C. H. Snyder & Son, Freehold, N. J.	Freehold	15.10	4.41	2.93
3361	Kentucky Winter	I. S. Stover, Philadelphia, Pa.	Stockton	17.82	4.39	5.67
3404	White	H. E. Taylor, Englishtown, N. J.	Englishtown	12.29	2.67	0.83
3452	No. 1 Fancy White	Taylor Bros., Camden, N. J.	Camden	17.77	4.57	2.12
3527	No. 2 Fancy White	Taylor Bros., Camden, N. J.	Chew's Landing	17.58	3.90	2.68
3481	No. 1 White	Taylor Bros, Camden, N. J.	Mt. Holly	17.58	5.35	3.60
3363	White	W. & W. E. Thomas, Milford, N. J.	Milford	16.74	4.13	2.50
3391	White	Trenton Mills and Elevator Co., Trenton, N. J.	Trenton	15.89	4.52	3.96
3323	White	C. W. Wagar & Co., Philadelphia, Pa.	Somerville	15.01	2.55	1.30
3638	Shorts	C. W. Wagar & Co., Philadelphia, Pa.	New Brunswick	17.31	5.94	4.54
3610	No. 1 White	Warr & Canby, Philadelphia, Pa.	Egg Harbor City.	16.22	5.82	4.90
3533	Winter White	Jonathan Webster, Woodstown, N. J.	Woodstown	17.07	3.04	0.99
3149	White	F. C. Williams, Easton, Pa.	Andover	19.51	5.14	3.59
3436	Shorts	Wyckoff's Mills, Turkey, N. J.	Turkey	14.54	4.10	2.81
		Average		16.67	4.56	3.29

WHEAT.

FLOUR MIDDLINGS.

Station number.	TITLE.	MANUFACTURER, JOBBER OR DEALER.	PLACE OF SAMPLING.	Protein.	Fat.	Fiber.
				%	%	%
3155	White	M. F. Baringer, Philadelphia, Pa	Sussex	19.88	5.27	1.60
3236	Fancy White	Duluth Superior Milling Co., Duluth, Minn	Dover	17.50	4.22	3.05
3014	White	Hecker-Jones-Jewell Milling Co., New York City	Jersey City	18.50	5.40	1.54
3016	Flour	Hecker-Jones-Jewell Milling Co., New York City	Jersey City	18.87	5.30	1.56
3025	No. 2 Flour	Hecker-Jones-Jewell Milling Co., New York City	Jersey City	19.51	5.43	1.65
3020	Best	Holly & Smith, Hackensack, N. J.	Hackensack	21.15	6.58	1.84
3021	White	Long Dock Mills and Elevator Co., Jersey City, N. J.	Jersey City	19.06	5.25	2.54
3620	Flour	Northwestern Cons. Milling Co., Minneapolis, Minn	Erma	18.16	6.15	5.62
3658	Flour	Geo. D. Stevens & Co., Minneapolis, Minn	Woodstown	17.82	5.88	6.47
3047	White	Strong, Lefferts & Co., N. Y. City	Passaic	20.31	4.22	2.65
3530	Flour	Washburn-Crosby Co., Minneapolis, Minn	Woodstown	17.96	5.79	6.16
3032	Snow's Cream White	E. S. Woodworth & Co., Minneapolis, Minn	Closter	20.50	5.45	2.10
3064	Snow's Cream White	E. S. Woodworth & Co., Minneapolis, Minn	Paterson	19.35	5.16	2.06
		Average		19.12	5.38	2.99

WHEAT.

BROWN MIDDLINGS.

Station number.	Title.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein	Fat.	Fiber.
				%	%	%
3097	Brown	Aberdeen Milling Co., Aberdeen, S. D.	Branchville	18.50	5.26	4.17
3392	Flour	W. S. Ankeny & Co., Minneapolis Minn	Red Bank	16.88	5.16	6.74
3495	Shorts	Beltz Bros. Co., Minneapolis, Minn.	Mullica Hill	19.41	6.80	6.02
3417	Brown	C. T. Birkett, Penyan, N. Y	Long Branch	15.38	4.43	3.48
3496	Standard	L. Christian & Co., Minneapolis Minn	Woodstown	18.38	5.67	6.47
3257	Brown	M. M. Connett, Brookside, N. J.	Troy Hills	20.38	4.35	4.61
3259	Brown	Consolidated Milling Co., Minneapolis, Minn	Newark	16.88	6.01	9.55
3012	Brown	C. B. Demarest, Hackensack, N. J.	Hackensack	19.25	5.69	5.40
3558	Brown	Eastern Milling and Expt. Co., Philadelphia, Pa	Salem	18.10	5.79	4.53
3033	Brown	Empire Mills, Olean, N. Y.	Closter	17.58	4.96	7.13
3261	Brown	Fish & Co., New York City	Madison	16.19	3.97	2.99
3214	Red Dog	Milton Flory, Bangor, Pa	Hackettstown	17.81	5.49	5.71
3217	Brown	James Gardner, Dover, N. J.	Dover	18.18	5.53	3.83
3036	Brown	Hecker-Jones-Jewell Milling Co., New York City	Passaic	17.25	5.18	7.00
3586	Spring	J. A. Hinds & Co., Rochester, N. Y.	Bridgeton	20.91	7.23	4.83
3037	Brown	Holly & Smith, Hackensack, N. J.	New Milford	19.94	6.28	6.75
3166	Brown	Howell & Webster, Middletown, N. Y.	Sussex	18.46	5.05	5.73
3038	White	G. W. Kennedy & Son, Shelbyville, Ind	Passaic	18.50	4.95	5.84
3043	Brown	Long Dock Mills and Elevator Co., Jersey City, N. J.	Passaic	19.06	5.64	7.19
3563	Shorts	C. B. Lummis, Cedarville, N. J.	Bridgeton	19.08	6.04	4.64
3395	Brown	John D. Macky, Philadelphia, Pa.	Matawan	18.19	4.66	5.60
3197	Brown	G. K. & O. H. McMurtrie, Belvidere, N. J.	Belvidere	18.28	6.76	4.63
3075	Brown	Meyer & De Vogel, Paterson, N. J.	Paterson	17.67	4.35	5.08
3300	Colonial	Miner-Hilliard Milling Co., Wilkes-bar.e, Pa	Plainfield	14.73	7.73	6.15
3145	Shorts	Montevideo Roller Mills, Montevideo, Minn	Newton	18.14	5.53	4.83
3080	Brown	N. Y. City Milling Co., N. Y. City	Paterson	17.63	5.46	7.97
3520	Brown	Northern Milling Co., Chicago, Ill.	Gloucester	20.00	5.01	4.98
3058	Middlings	Perth Amboy Grain Co., Perth Amboy, N. J.	Perth Amboy	16.60	4.55	4.72

WHEAT.

BROWN MIDDLINGS—Continued.

Station number.	Title.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
				%	%	%
3267	Brown	Pilsbury Flour Co., Minneapolis, Minn.	Newark	17.06	5.69	8.58
3356	Winter	Quaker City Milling Co., Philadelphia, Pa.	Frenchtown	13.88	4.73	4.75
3398	Brown	M. G. Rankin & Co., Milwaukee, Wis.	Englishtown	18.57	4.70	4.29
3339	Fine Brown	A. Rockafellew, Flemington, N. J.	Flemington	17.77	6.33	3.99
3039	Brown	Shelby Milling Co., Shelby, O.	Closter	17.38	4.42	4.84
3250	Fancy Winter	Simpson, Hendee & Co., N. Y. City.	Morristown	17.30	4.82	5.29
3447	Brown	Sitley & Son, Camden, N. J	Camden	17.82	4.45	4.20
3359	Middlings	Jos. Smith & Co., Stockton, N. J.	Stockton	13.73	4.26	2.80
3454	Brown	Taylor Bros., Camden, N. J.	Camden	18.10	5.16	5.97
3484	Shorts	Taylor Bros., Camden, N. J.	Mt. Holly	17.44	4.96	5.96
3302	Brown	C. W. Wagar & Co., Philadelphia, Pa	Elizabeth	20.63	6.02	5.84
3274	Standard	Washburn-Crosby Co, Minneapolis, Minn.	Whippany	19.23	5.86	6.84
3050	Brown	Wilkinson, Gaddis & Co., Newark, N J.	Passaic	16.13	5.74	10.17
3276	Winter	Wilkinson, Gaddis & Co., Newark, N. J.	Newark	17.07	4.37	4.51
3322	Middlings	W. H. H. Wyckoff, Raritan, N. J.	Raritan	17.44	5.34	4.69
		Average		17.84	5.36	5.59

RED MIDDLINGS.

3015	Red	Hecker-Jones-Jewell Milling Co., N. Y. City.	Jersey City	18.25	5.81	2.22
3049	Red	Wm. Veldrans' Sons, Oradell, N. J.	Westwood	18.38	5.01	4.95
3024	Red	Watson Milling Co., Wichita, Kan.	Jersey City	18.75	5.49	6.68
		Average		18.46	5.44	4.62

WHEAT AND RYE MIDDLINGS.

3517		W. G. Kirby, Medford, N. J.	Medford	15.85	4.52	3.08

RYE.

RYE FEED OR CHOP.

Station number.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
			%	%	%
3280	W. N. Adair & Co., Raritan, N. J	Plainfield	10.81	1.61	1.10
3138	Milton Flory, Bangor, Pa	Newton	*12.19	*2.93	*1.90
3503	H. A. Ford, Allentown, N. J	Allentown	9.39	1.66	1.83
3420	C. E. Hall, Turkey, N. J	Turkey	10.35	1.99	1.71
3546	M. E. Lamb, New Egypt, N. J	New Egypt	9.95	1.92	1.65
3118	McDonalds & Lance, Branchville, N. J	Branchville	10.51	1.73	1.51
3426	E. C. Norton, Hightstown, N. J	Hightstown	9.21	1.56	1.66
3477	Rogers & French, Mt. Holly, N. J	Mt. Holly	9.66	1.72	1.92
3402	C. H. Snyder & Son, Freehold, N. J	Freehold	9.57	1.60	1.56
3405	H. E. Taylor, Englishtown, N. J	Matawan	9.28	1.95	1.56
3410	Wm. N. Stewart, Englishtown, N. J	Red Bank	8.72	1.71	1.71
	Average		9.75	1.74	1.62

RYE MIDDLINGS.

3193	Belvidere Flour Mill Co., Belvidere, N. J	Belvidere	12.63	2.33	1.18
3199	G. K. & O. H. McMurtrie, Belvidere, N. J	Belvidere	13.72	2.50	1.82
3201	Meurer, Deutsch & Sickert Co., Milwaukee, Wis	Danville	15.25	3.33	3.72
3528	J. R. Wilkinson, Vincentown, N. J	Vincentown	*9.57	*2.06	*0.70
	Average		13.87	2.72	2.24

*Not included in the average.

BUCKWHEAT BRAN OR MIDDLINGS.

Station number.	Title.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
				%	%	%
3144	Middlings	Lawrence & Harden, Sussex, N. J.	Sussex	36.03	10.01	2.97
3107	Bran	C. H. Crisman, Branchville, N. J.	Branchville	35.13	10.63	2.44
3117	Bran	McDonalds & Lance, Branchville, N. J	Branchville	31.61	10.12	4.10
3200	Middlings	G. K. & O. H. McMurtrie, Belvidere, N. J	Belvidere	31.33	8.74	4.80
3366	Middlings	Worman Mills, Frenchtown, N. J.	Frenchtown	30.33	9.10	3.46
3360	Bran	Jos. Smith & Co., Stockton, N. J.	Stockton	29.26	7.71	2.17
3213	Bran	Nelson Dufford, Hackettstown, N. J	Hackettstown	28.19	8.13	2.21
3220	Bran	J. P. Hoffman, Hackettstown, N. J.	Hackettstown	27.50	7.86	2.01
3190	Middlings	Belvidere Flouring Mill Co., Belvidere, N. J.	Belvidere	27.06	7.67	2.99
3148	Bran	S. S. Wills, Andover, N. J.	Andover	25.41	6 92	2.72
3497	Bran	I. S. Daws, Red Valley, N. J.	Red Valley	22.74	7.92	8.76
3529	Bran	J. R. Wilkinson, Vincentown, N. J.	Vincentown	20.44	5.28	8.11
3516	Bran	W. G. Kirby, Medford, N. J	Medford.	19.71	5.10	23.50
3641	Middlings	McKeown & Spence, New York City	New Brunswick	18.83	5.04	3.25
3622	Middlings	W. H. Prettyman, Lewes, Del.	Cape May	18.83	5.26	2.78
3174	Middlings	W. H. Ingersoll, Hamburg, N. J.	Hamburg	17.44	4.74	1.28
3334	Bran	G. G. McPherson, Lebanon, N. J.	Lebanon	15.01	4.36	15.28
3330	Bran	L. L. Holcombe, Flemington, N. J.	Flemington	14.19	3.68	1.50

BARLEY FEED AND MEAL.

3202	Feed	Meurer, Deutsch & Sickert Co., Milwaukee, Wis.	Danville	14.19	4.81	8.78
3269	Meal	Allen V. Smith, Marcellus Falls, N. Y.	Newark	16.79	4.60	7.38

WHOLE GRAINS GROUND TOGETHER.

CORN AND OATS.

Station number.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
			%	%	%
3612	S. Anderson, Hammonton, N. J.	Hammonton	10.62	5.25	3.73
3631	[1]P. E. Apgar, Weston, N. J.	New Brunswick	9.33	2.87	4.12
3632	Herman Banker, New Brunswick, N. J.	New Brunswick	*15.64	*3.66	*4.21
3010	Carscallen & Cassidy, Jersey City, N. J.	Jersey City	9.56	4.71	3.87
3498	I. S. Daws, Red Valley, N. J.	Red Valley	9.28	1.19	1.99
3262	G. F. Freeman, Whippany, N. J.	Whippany	10.75	4.24	3.34
3284	C. F. French, Plainfield, N. J.	Plainfield	9.81	3.94	3.09
3332	Ira Hill, Copper Hill, N. J.	Copper Hill	9.74	4.71	3.81
3331	L. L. Holcomb, Flemington, N. J.	Flemington	10.48	4.43	2.67
3352	E. L. Hunt, Lambertville, N. J.	Lambertville	9.66	4.26	2.87
3394	[2]Long Dock Mills and Elevator Co., Jersey City, N. J.	Matawan	10.69	3.94	3.87
3425	E. C. Norton, Hightstown, N. J.	Hightstown	9.59	3.87	2.74
3403	C. H. Snyder & Son, Freehold, N. J.	Freehold	9.76	4.06	3.16
3272	W. Stull & Bro., Madison, N. J.	Madison	10.23	4.06	3.87
3048	[3]Wm. Veldrans' Sons, Oradell, N. J.	Westwood	10.69	4.52	5.21
3408	[4]Wilkinson, Gaddis & Co., Newark, N. J.	Matawan	9.05	2.89	6.43
3435	M. G. & A. P. Wyckoff, Manasquan, N. J.	Manasquan	10.23	4.18	2.36
	Average		9.97	3.95	3.57

*Not included in the average.
[1]Stock of C. W. Russell.
[2]Stock of Cartan & Devlin.
[3]Stock of E. P. Voorhis & Co.
[4]Stock of W. A. Close.

WHOLE GRAINS GROUND TOGETHER.

MISCELLANEOUS GRAINS.

Station number.	Manufacturer, Jobber or Dealer.	Ingredients.	Protein.	Fat.	Fiber.
			%	%	%
3311	[1]W. N. Adair & Co., Raritan, N. J.	Corn, oats, rye	11.26	4.17	2.34
3613	S. Anderson, Hammonton, N. J.	Corn, oats, rye	10.43	3.68	3.50
3297	A. L. Cadmus, Plainfield, N. J.	Corn, oats, rye	10.69	4.10	2.79
3256	[2]M. M. Connett, Brookside, N. J.	Corn ears, oats, middlings	8.69	3.67	5.21
3108	C. H. Crisman, Branchville, N. J.	Rye, oats, corn, wheat bran	10.38	2.86	4.27
3211	Nelson Dufford, Hackettstown, N. J.	Corn ears, oats	7.75	3.42	7.49
3212	Nelson Dufford, Hackettstown, N. J.	Corn, oats, rye	9.00	3.13	3.88
3055	[3]Flemington Mill. Co., Flemington, N. J.	Corn, oats, light wheat or rye	9.46	4.43	2.05
3328	Flemington Mill. Co., Flemington, N. J.	Corn, oats, wheat screenings	10.67	4.73	2.11
3314	[4]C. F. French, Plainfield, N. J.	Corn, oats, rye	9.76	3.25	3.25
3115	[5]J. R. Hagerman, Mt. Bethel, Pa.	Rye, corn, oats	10.76	2.89	1.93
3219	J. P. Hoffman, Hackettstown, N. J.	Rye, oats (Boss Feed)	11.73	2.84	3.86
3221	J P. Hoffman, Hackettstown, N. J.	Corn, oats, rye	12.11	3.29	4.36
3242	Jaqui & Co., Morristown, N. J.	Corn, oats, rye (No. 1)	10.48	5.15	6.22
3222	Wm Larison, Washington, N. J.	Corn ears, rye, oats	10.11	4.19	6.00
3353	F. F. Lear, Lambertville, N. J.	Corn, oats, rye	9.40	3.68	2.13
3335	G. G. McPherson, Lebanon, N. J.	Corn, oats, rye	9.96	3.31	2.81
3244	Miller & Mott, Rockaway, N. J.	Corn, middlings, oats	15.66	4.86	2.65
3224	Opdyke & Son, Washington, N. J.	Rye, corn, oats	8.68	2.86	9.11
3225	[6]Hiram Parcell, Glen Gardner, N. J.	Corn ears, rye, oats	8.30	3.42	5.94
3338	E. V. Parry, Clinton, N. J.	Corn, oats, rye	9.59	3.72	2.58
3432	H. B. Sherman & Sons, Long Branch, N. J.	Corn, rye, oats	9.85	4.03	3.43
3358	Jos. Smith & Co, Stockton, N. J.	Rye, cracked corn	9.38	2.56	1.49
3364	W. & W. E. Thomas, Milford, N. J.	Corn, wheat screenings, oats	9.76	4.28	1.77
3125	Van Winkle Grain and Feed Co., Paterson, N. J.	Corn, rye, oats (No. 1)	9.76	3.63	4.08
3251	[7]F. C. Williams, Easton, Pa.	Corn, oats, rye	11.16	3.95	3.20
3060	[8]W. H. H. Wyckoff, Raritan, N. J.	Corn, oats, rye	9.76	3.36	3.56
	Average		10.17	3.67	3.78

[1]Stock of P. Trainer, Westfield.
[2]Stock of E. H. Ball, Troy Hills.
[3]Stock of J. H. Jennings, Rahway.
[4]Stock of H. C. Meyer, Scotch Plains.
[5]Stock of Hopkins & Williams, Newton.
[6]Stock of J. M. Fitts & Son, Washington.
[7]Stock of F. F. Birch, Dover.
[8]Stock of A. M. Metzendorf, Perth Amboy.

MISCELLANEOUS MATERIALS.

PEANUT BRAN.

Station number.	Manufacturer, Jobber or Dealer.	Place of Sampling.	Protein.	Fat.	Fiber.
			%	%	%
3600	Wilkinson, Gaddis & Co.	Newark	6.18	1.95	13.29
3662	Received from New York	New York	10.75	6.77	15.17

PEANUT MIDDLINGS.

3601	Wilkinson, Gaddis & Co.	Newark	9.68	6.53	39.26

PEANUT VINE.

3661	Received from New York	New York	13.88	12.20	48.05

II.

MARKET PRICES OF COMMERCIAL FEEDS.

The effect of the high prices of the past few years, which reached their culmination in 1902, is still noticeable in the prices of feeds this year, although all feeds show a decrease in price, with the exception of Chicago Gluten Meal and the H. O. Feeds. This decrease varied from $4.98 in Vim Oat Feed to 25 cents in Maizeline Feed, with an average decrease for all feeds of $1.81 per ton. Notwithstanding this decrease, however, the prices of feeds are still very high. Compared with the prices in 1901, the feeds rich in protein, cottonseed, linseed, germ oil and gluten meals and gluten feeds are $1.89 per ton higher; the brewery products, $2.31 higher; the by-products of the milling of wheat, rye and buckwheat, $3.13 higher; the feed mixtures consisting chiefly of corn and inferior oats, $4.68 higher; while hominy meal, cerealine feed, maizeline feed and corn bran, feeds entirely derived from corn, are $5.44 higher. The shortage of the corn crop in 1900–01 still shows its effect in the prices of all corn products, and continues to have a sympathetic influence on the prices of all other feeds. The average prices of all feeds in 1903 was $24.29 per ton, compared with $25.96 and $20.57 per ton in 1902 and 1901, respectively.

KIND OF FEED.	Jan. 1st, 1898.	Jan. 1st, 1899.	Jan. 1st, 1900.	May 1st, 1901.	May 1st, 1902.	May 1st, 1903.
	AVERAGE FOR THE SIX MONTHS PRECEDING					
Cottonseed Meal	$23 00	$20 22	$25 33	$28 70	$30 79	$29 85
Linseed Meal	24 32	25 30	28 94	34 08	35 50	32 27
Germ Oil Meal	.....	.....	.....	22 75	26 50	24 00
Chicago Gluten Meal	16 83	19 83	22 42	26 08	29 50	31 00
Gluten Feeds	15 22	15 92	18 41	21 87	27 30	25 81
Hominy Meal	13 94	15 94	17 00	19 05	27 77	25 62
Cerealine Feed	.....	.....	.....	19 75	27 69	24 86
Maizeline Feed	.....	.....	.....	19 50	26 75	26 50
Corn Bran, or Sugar Feed	.....	.....	.....	17 10	21 15	20 17
Malt Sprouts	12 08	14 58	15 89	17 50	21 37	18 69
Dried Brewers' Grains	15 13	14 92	17 67	19 06	22 73	20 06
Dried Distillers' Grains	.....	.....	.....	.....	21 67	18 50
Sucrene Dairy Feed	.....	.....	.....	21 00	25 25	.....
Schumacher Corn, Oats and Barley Feed	.....	.....	.....	20 00	30 75	28 67
Local Feed Mixtures	.....	.....	.....	20 68	26 97	25 91
Quaker Dairy Feed	.....	.....	.....	18 86	24 56	20 44
Victor Corn and Oat Feed	.....	.....	.....	18 55	25 61	22 90
Vim Oat Feed	.....	.....	.....	16 10	20 58	15 60
De Fi Corn and Oat Feed	.....	.....	.....	19 00	25 00	.....
Friend's Feed	.....	.....	.....	16 13	23 25	.....
Boss Corn and Oat Feed	.....	.....	.....	.....	23 50	22 30
Royal Oat Feed	.....	.....	.....	16 00	19 50	16 57
H. O. Dairy Feed	.....	.....	.....	22 70	29 00	29 33
H. O. Horse Feed	.....	.....	.....	21 88	29 99	30 00
Monarch Oat Chop	.....	.....	.....	.....	26 00	25 00
Wheat Bran	14 10	15 43	17 48	21 13	25 95	22 12
Wheat Middlings	15 85	17 87	19 15	22 63	28 75	25 28
Brown Middlings	.....	.....	.....	.....	27 00	25 28
Feeding Flour	.....	.....	.....	.....	28 33	27 40
Wheat Feed	.....	.....	.....	19 75	25 75	22 26
Buckwheat Bran	.....	.....	.....	.....	22 00	20 13
Buckwheat Feed	.....	.....	.....	.....	20 00	20 13
Rye Bran	12 44	14 69	17 22	17 50	23 00	.....
Rye Middlings	15 50	16 97	18 60	18 00	25 00	24 25
Rye Feed	.....	.....	.....	23 00	25 25	24 36
Corn Meal	15 02	16 62	17 25	22 00	28 95	.....
Corn Ear Meal	13 67	15 92	14 33	15 41	23 80	.....
Corn and Oats (Provender)	16 69	19 79	19 81	20 90	29 69	28 57
Mixed Grains	.....	.....	.....	21 56	28 33	27 81

CHANGES IN THE COMPOSITION OF CORN MEAL DUE TO THE ACTION OF MOULDS.

BY JOHN PHILLIPS STREET.

In a previous bulletin[1] of this Station there was reported a preliminary series of experiments to study the effect of the common green mould, *Penicillium glaucum,* on the composition of corn meal. Those experiments, although only covering the short period of nine days, showed conclusively that the growth of the mould, under proper conditions of moisture, occasioned large losses of fat and but slight losses of protein. The experiments herewith reported were planned on a more elaborate scale, and were intended for a study of the changes in the different food compounds of corn meal due to moulds, as well as a study of the moisture conditions most favorable to their growth and development. The experiments were suggested by the fact that during the feeding inspection of 1902 in this State a large number of samples of corn meal was found whose fat content was abnormally low. It was inferred that the shortage in the corn crop during that season had prevented the proper drying out of the corn before grinding, and consequently the increased content of moisture supplied conditions favorable to the growth of moulds, the spores of some of which are generally present in many farm products. This inference was confirmed by the experiments already alluded to.

Plan of Experiment.

These experiments were conducted in two general series; in the first series small quantities of corn meal were used, and, after being acted upon by the mould for varying periods, were examined for moisture, protein and fat; in the second series large amounts of the meal were employed and a more complete food analysis was made, in order to study the effect of the mould on the different food compounds.

A normal sample of corn meal was prepared and analysed, showing the following composition:

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[1] N. J. Agl. Expt. Station, Bulletin 160, pp. 72–76.

	In Original Material.	In Water-Free Material.
	%	%
Water	11.517	......
Fat	3.860	4.363
Fiber	1.590	1.797
Protein	9.563	10.808
Albuminoids	9.450	10.680
Ash	1.525	1.723
Carbohydrates	71.945	81.309

It was intended to make a complete analysis of the corn meal, but pressure of other duties prevented. However, below will be found such an analysis calculated from the more detailed analyses of other workers with the different food compounds of corn meal; the analyses of Hopkins are used for the fat compounds, those of Osborne for the proteids and those of Stone for the carbohydrates.

The figures marked with an asterisk represent the author's analyses in this particular sample.

Chemical Composition of Corn Meal.

	%	
Water	*11.517	
Total Fats	*3.860	
Cholesterol		0.053
Lecithin		0.058
Stearin		0.141
Olein		1.739
Linolin		1.869
Total Proteids	*9.563	
Proteose, sol. in water		0.060
Globulin, very sol.		0.040
Maysin, sol. in dilute salt sol.		0.250
Edestin, sol. in more concentrated salt sol.		0.100
Zein, sol. in alcohol		4.960
Sol. in dilute alkalies		3.123
Insol. in any of above solvents		1.030
Ash	*1.525	
Carbohydrates	*73.535	
Sucrose		0.247
Dextrin		0.293
Starch		66.707
Peutosaus		4.698
Fiber		*1.590

Before giving the details of the experiment, it seemed desirable to give a short description of the mould and of the nature of its activities.

Description of the Mould.

Penicillium glaucum belongs to the class *Ascomycetes* of the higher fungi and to the subclass *Perisporiaceæ.* It is closely allied with *Eurotium* and *Aspergillus,* and is the most frequently occurring of all moulds. According to Cramer[2] its spores consist of a nucleus of concentrated albuminoids surrounded by a mantle of cellulose and starch-like carbohydrates filled with very hydroscopic fatty bodies, which are solublue in alcohol, showing the following percentage composition in the dry substance:

Albuminoids	28.44
Ether extract	7.34
Alcohol extract	30.46
Starch	17.00
Cellulose	11.13
Ash	1.91
Undetermined	3.72

There is some question, however, as to the above description of Cramer, for C. van Wisselingh[3] has invariably detected chitin in the cell walls of *P. glaucum,* and according to Lafar[4] there is at present no known instance where cellulose and chitin occur simultaneously in the cell membrane of a fungus. The difficulty probably lies in the mistake of confounding fungus-cellulose with true cellulose, the former doubtless being an isomer or analogue of what we know as the cellulose proper. Lafar[5] also questions the presence of starch in the conidia of this mould, believing the blue iodine reaction noted by several observers to be due possibly to the presence of an isolichenin. Nor, according to Burgerstein, Niggl and Harz,[6] is there any liquefication of the cell membrane. The membranes of the conidia of *P. glaucum* are waterproof in character, attributed by some to the deposition of excreted fatty or waxy substances. This is important biologically, as it prevents the penetration of toxic substances, and therefore opposes all efforts of the mycologist to kill the fungi by means of aqueous toxic solutions[7] (Lafar, II., 40).

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[2] Arch. für Hyg., 1894, 20, pp. 197–205.
[3] Lafar's Mycology, English ed., Vol. 2, pt. 1, p. 37.
[4] Lafar's Mycology, English ed., Vol. 2, pt. 1, p. 37.
[5] Lafar's Mycology, English ed., Vol. 2, pt. 1, p. 38.
[6] Lafar's Mycology, English ed., Vol. 2, pt. 1, p. 39.
[7] Lafar's Mycology, English ed., Vol. 2, pt. 1, p. 40.

Enzymes and their Secretion by Penicillium Glaucum.

Much of the action of bacteria, and of moulds in particular, is due to the enzymes, or soluble ferments, which they secrete. In spite of the uncertainty as to the exact nature of these ferments, the theory of Arthus[8] that they are not chemical substances, but may be imponderable agents like heat, light or electricity, has not been demonstrated, and while the theory of enzyme-substance likewise is as yet undemonstrated, the latter seems the more probable. It is generally assumed, therefore, that enzymes are active organic substances secreted by cells, and have the property of facilitating chemical reactions between certain bodies without entering into the composition of the definite products which result. The action of enzymes is both analytic and synthetic, forming very complex substances synthetically, and resolving complex into simple substances analytically. In the synthetic process, for instance, we may have protoplasm formed at the expense of sugar and nitrates, while analytically albuminoid matters may change first into proteoses, then into peptones, amides and finally ammonia, hydrogen sulphide, oxalic and carbonic acids.[9] Moreover, these two processes, the analytic and the synthetic, go on together. Further, enzymes produce heat in living organisms, and while encouraging the decomposition of the albuminoid molecule into urea, glycogen, fatty substances and amides, the cells select the peptones as tissue-building materials, the urea being attacked and transformed into ammonium carbonate.

Enzymes may cause a molecular change, a hydration or an oxidation, and have their maximum activity at a temperature from 40° to 50° C. They possess the remarkable property of causing changes entirely disproportionate to their quantity; for instance, rennin can coagulate 250,000 times its weight of casein.[10]

The distribution of enzymes in nature is quite general. Not only are they found in the saliva, the pancreatic juice, the gastric juice and the intestinal secretions of animals, but they also have a wide distribution in the vegetable kingdom, even in the lower forms, such as yeasts, fungi and bacteria.

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[8] M. Arthus, Nature des enzymes, Paris, 1896.

[9] Effront's Enzymes and Their Applications, English ed., 1902, p. 2.

[10] Effront's Enzymes and Their Applications, English ed., 1902, p. 33.

Maize has been found to contain several enzymes, among which are maltase, amylase, cytase, sucrase, which are hydrating ferments, and lipase or steapsin, a ferment of fatty substances. Of these enzymes, maltase is the most abundant, the others existing, as a rule, only at certain stages in the development of the plant; amylase, for instance, being found seldom except during the period of germination. Had the meal used in these experiments not been subjected to a high temperature during sterilization, it might have been possible that some of the changes noted were due to the enzymes in the maize itself, but as most of the enzymes are either destroyed or rendered inactive at a high temperature, we must look elsewhere for an explanation of the changes noted later.

Numerous investigators have found that many bacteria and moulds, *Penicillium glaucum* in particular, also secrete certain enzymes. Bourquelot[11] discovered that both *Aspergillus niger* and *P. glaucum* secreted an enzyme, trehalase, which acts on trehalose and, by hydrolysis, forms glucose. J. R. Green[12] has observed inulase in *P. glaucum,* an enzyme which transforms the reserve substance, inulin, into levulose by hydrolysis. Effront has stated[13] that the destruction of vegetable tissues by moulds must be attributed to a secretion of cytases. Cytase leads to the assimilation of cellulose by vegetable cells, which is preceded by liquefaction and a more or less complete transformation, carbon di-oxid being liberated and possibly marsh gas. It has the property of dissolving the cellulose envelope of the grains of starch, a slight acidity being very favorable to its secretion. While, according to some authors, amylase is found in moulds, its occurrence in *P. glaucum* is very rare. Its action is to hydrate the starch, transforming it into maltose and dextrins.[14] Sucrase is also of very common occurrrence in the vegetable kingdom, and many moulds, among them *P. glaucum,* secrete it and effect the inversion of saccharose, cane sugar, into dextrose and levulose.[15] A great number of moulds possess the power of transforming starch into sugar, and there is every reason to believe that they render starch assimilable by the aid of the maltase or glucase they secrete. Laborde[16] has

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[11] Soc. de biol., 1893, June.

[12] Annals of Botany, 1888, 1893.

[13] Effront, p. 255.

[14] Effront, p. 100.

[15] Effront, p. 51.

[16] Recherches physiol. sur une moisissure d' Eurotiopsis Gayoni, Ann. de l'Inst. Pasteur, 1898.

found that in the case of *P. glaucum* and certain other moulds there is a direct transformation without the intermediate formation of maltose.

But the enzymes of moulds are not confined alone to those which act on carbohydrates. The ferment, steapsin or lipase, a secretion of the pancreatic juice, has the power of splitting fats into fatty acids and glycerin. An active substance showing all the properties of lipase has been found by Gérard[17] in *P. glaucum.* This action is hydrolytic in its nature, giving rise to a complex reaction in three stages forming two intermediate products, diglycerides and mono-glycerides. According to Thum,[18] the free acids do not consist solely of oleic acid, but of a mixture in exactly the same proportions as that in which they exist in the undecomposed glycerides. Saponification breaks the fat up into glycerin and fatty acids, and then leads to the conversion of the latter, especially oleic acid, into oxy-compounds.

P. glaucum secretes still another class of enzymes, namely, emulsin, which acts on glucosides.[19]

The following tabulation shows a summary of the enzymes, which may be secreted by *P. glaucum,* the compounds upon which they act and the products resulting from this action:

Enzyme.	Acts on.	Product.
Trehalase	Trehalose	Glucose.
Inulase	Inulin	Fructose and levulose.
Cytase	Cellulose	Sugars.
Sucrase	Cane sugar	Invert sugar.
Amylase	Starch and dextrin	Maltose.
Maltase	Dextrin and maltose	Dextrose.
Emulsin	Amygdalin and other glucosides	Glucose, oil of bitter almonds and hydrocyanic acid.
Lipase	Fats	Glycerin and fatty acids.

Series I.

On November 20th forty portions of two grams each of the corn meal were weighed into tared fat extraction tubes, the lower ends of which were covered with a thin layer of asbestos over fine copper

[17] Comptes rendus, 1897, p. 370.
[18] Wright's Fixed Oils, Fats, Butters and Waxes, 1894, p. 12.
[19] Bourquelot and Herissey, Note concernant l'action de l'emulsine de l'Aspergillus niger, etc., etc., Soc. de Biologie, 1895.

gauze. On the same day the following approximate amounts of water were added to the different sub-series:

			Water Added.
Sub-series	A,	Nos. 1–8	0
"	B,	" 11–18	0.2 gm.
"	C,	" 22–29	0.4 "
"	D,	" 32–39	0.5 "
"	E,	" 42–49	0.9 "

The tubes containing the meal, after being plugged with absorbent cotton, were placed in a sterilizer on November 21st, and, after sterilization, all were inoculated with pure cultures of *Penicillium glaucum*. The pure cultures of the mould were prepared and the sterilization of the meal was conducted by Mr. J. G. Lipman, the bacteriologist of this Station, and the author hereby expresses his appreciation of his kind assistance.

The following tabulation shows the scheme of the experiment in detail:

Scheme of Experiment.

NUMBER OF SUB-SERIES.	Number of test.	Duration of test.	Water content at beginning.	NUMBER OF SUB-SERIES.	Number of test.	Duration of test.	Water content at beginning.
		Days.	Per cent.			Days.	Per cent.
A................	1	21	11.52	C................	26	56	26.00
A................	2	21	11.52	C................	27	56	25.69
A................	3	42	11.52	C................	28	77	25.05
A................	4	42	11.52	C................	29	77	26.32
A................	5	56	11.52	D................	32	21	28.44
A................	6	56	11.52	D................	33	21	49.80
A................	7	77	11.52	D................	34	42	26.99
A................	8	77	11.52	D................	35	42	28.93
B................	11	21	18.41	D................	36	56	28.88
B................	12	21	19.24	D................	37	56	28.63
B................	13	42	19.90	D................	38	77	29.04
B................	14	42	20.45	D................	39	71	29.23
B................	15	56	18.68	E................	42	21	38.07
B................	16	56	18.62	E................	43	21	38.72
B................	17	77	18.64	E................	44	42	38.75
B................	18	77	18.69	E................	45	42	38.24
C................	22	21	25.18	E................	46	56	38.71
C................	23	21	25.65	E................	47	56	38.24
C................	24	42	25.35	E................	48	77	37.95
C................	25	42	25.19	E................	49	77	39.67

In adding water to the meal it was intended that all the tests of each sub-series should contain approximately the same amount of moisture. As the amounts added were very small, ranging from

0.2 to 0.9 cc., slight variations necessarily occurred, but in no case, except in test 33, was this variation of any consequence.

Moisture Content of Sub-Series.

				Average.
Sub-series	A,	from 11.52	to 11.52 %	11.52 %
"	B,	" 18.41	" 20.45 %	19.08 %
"	C,	" 25.05	" 26.32 %	25.47 %
"	D,	" 26.99	" 29.23 %	28.72 %
"	E,	" 37.95	" 39.67 %	38.41 %

By an accident 1.5249 gms., instead of 0.4 gms., of water was added to test 33, but it was continued in the experiment for the purpose of ascertaining the effect of a very large moisture content, 49.80 per cent., on the activity of the mould.

Method of Experiment.

After inoculation with the mould the tubes were restoppered with plugs of absorbent cotton and placed in glass beakers under five bell-jars, each jar containing eight tubes. The tubes in each jar were those containing approximately the same amount of moisture. An open test tube partially filled with distilled water was also supplied to each jar to preserve a moist, but not saturated, atmosphere. The jars rested on flat, glass dishes, covered with a thick layer of absorbent cotton. No effort was made to preserve the original moisture content during the experiment, and a gradual drying out was observed in every case, until at the end of eleven weeks the meals were practically in equilibrium as regards moisture, varying from 6.90 to 7.21 per cent. It was thought that by allowing this gradual drying out the results would be more in harmony with those likely to be obtained by the farmer or miller in actual practice, and not simply laboratory theorizations.

At the end of periods of twenty-one, forty-two, fifty-six and seventy-seven days, two tests were removed from each jar, and, after weighing, water, fat and protein were determined therein, the two tests of each sub-series being considered as duplicates.

The results of these analyses appear in the following table, where the weight and percentage of water, fat and protein are given as found both at the beginning and at the end of the experiments, the figures in each case being the average of the duplicates of each test.

TEST.	WATER.				FAT.				PROTEIN.			
	WEIGHT.		PER CENT.		WEIGHT.		PER CENT.		WEIGHT.		PER CENT.	
	Beginning.	End.	Beginning.	End.	Beginning.	End.	Beginning.	End.	Beginning.	End.	Beginning.	End.
Period I.—21 days.	mgms.	mgms.	%	%	mgms.	mgms	%	%	mgms.	mgms.	%	%
1— 2	230.3	212.4	11.52	10.73	77.2	70.5	3.86	3.56	191.3	190.3	9.56	9.61
11—12	410.4	242.0	18.83	12.09	77.2	63.7	3.54	3.18	191.3	188.8	8.78	9.44
22—23	602.9	664.3	25.42	27.45	77.2	54.8	3.26	2.26	191.3	189.8	8.07	7.84
32	703.2	394.4	28.44	18.26	77.2	58.2	3.13	2 69	191.3	187.0	7.74	8.66
33	1755.2	1018.1	49.80	36.62	77.2	49.6	2.19	78	191.3	180.5	5.43	6.49
42—43	1100.0	691.7	38.40	28.20	77.2	54.1	2.69	2.21	191.3	181.2	6.67	7.52
Period II.—42 days.												
3— 4	230.3	143.0	11.52	7.41	77.2	67.5	3.86	3.50	191.3	190.4	9.56	9.87
13—14	447.2	147.1	20.18	7.60	77.2	58.5	3.49	3.02	191.3	188.5	8.61	9.72
24—25	598.6	166.8	25.27	8.64	77.2	39.4	3.26	2.04	191.3	186.6	8.07	9.67
34—35	687.3	152.4	27.96	7.86	77.2	53.8	3.14	2.77	191.3	186.2	7.78	9.61
44—45	1105.6	167.4	38.50	8.63	77.2	49.4	2.69	2.55	191.3	182.4	6.64	9.40
Period III.—56 days.												
5— 6	230.3	146.2	11.52	7.62	77.2	71.5	3.86	3.72	191.3	187.0	9.56	9.72
15—16	405.6	150.4	18.65	7.79	77.2	65.8	3.55	3.41	191.3	186.0	8.78	9.65
26—27	617.0	152.7	25.85	8.03	77.2	47.8	3.23	2.51	191.3	184.6	8.00	9.71
36—37	714.6	148.4	28.76	7.73	77.2	55.7	3.11	2.90	191.3	183.7	7.71	9.56
46—47	1104.2	138.7	38.48	7.25	77.2	55.3	2.69	2.89	191.3	180.0	6.65	9.39
Period IV.—77 days.												
7— 8	230.3	132.8	11.52	6.90	77.2	66.5	3.86	3.45	191.3	187.1	9.56	9.71
17—18	406.1	133.7	18.67	6.91	77.2	62.5	3.55	3.24	191.3	188.9	8.78	9.80
28—29	611.3	135.3	25.69	7.06	77.2	50.8	3.24	2.65	191.3	188.5	8.04	9.84
38—39	726.9	138.3	29.14	7.21	77.2	52.3	3.09	2.72	191.3	185.7	7.65	9.67
48—19	1121.9	136.3	38.81	7.12	77.2	50.3	2.67	2.63	191.3	183.9	6.62	9.61

Changes in Moisture Content.

As stated above, no effort was made to conserve the varying amounts of water added to the meal; on the contrary, the conditions were so arranged as to allow a gradual evaporation of the moisture. The following tabulation shows the percentage of moisture in the different sub-series at the beginning and at the end of the different periods, the results being calculated to a uniform moisture basis for each sub-series.

Per Cent. of Water.

Sub-series.	At Beginning.	After 21 Days.	After 42 Days.	After 56 Days.	After 77 Days.
A..........	11.52	10.73	7.41	7.62	6.90
B..........	18.83	12.09	7.09	7.87	7.02
C..........	25.42	27.45	8.69	7.90	6.99
D..........	28.44	18.26	8.00	7.64	7.04
E..........	38.40	28.20	8.61	7.23	7.04

The table shows that at the end of seventy-seven days all of the series were practically in equilibrium as regards moisture, and although it was planned to continue another series of tests for twenty-one days further, for this reason the experiment was terminated at the end of the period stated, eleven weeks. Under the predetermined conditions of the experiment, it is impossible to consider with any definiteness the effect of the mould on moisture content, but inasmuch as the losses in moisture during the second period of three weeks were, in all cases but one, considerably larger than in the first period, it is fair to assume that an increase of moisture took place during the earlier stages of the experiment, and that this increase was due solely to the moulds. This is shown very clearly in sub-series C, where, in spite of the opportunities given for the escape of moisture, and in spite of the fact that in all the other tests this opportunity was taken advantage of, the moisture content is increased from 25.42 to 27.45 per cent., or more than 2 per cent. This confirms the work of Spieckermann and Bremer[20] in similar experiments with moulds on cottonseed meal, in which they established the fact that a moisture content of from 24 to 30 per cent. was most favorable for the development of *Penicillium glaucum*. That the mould did thrive better under these

[20] Landw. Jahrb., 31, pt. 1, 1902, pp. 81–128.

conditions of moisture, and that consequently it attacked the fat of the meal with greater virulency, will be shown even more conclusively in a later part of this report.

Development of the Mould.

During the whole experiment the tests in sub-series A and B showed no visible mould, although there was a slight mouldy odor in B. The strongest development was observed in C, where it permeated the whole mass of the meal; it was also very pronounced in D and E. Of the different quantities of moisture used, 25.42 per cent. seemed to be most favorable to the mould, while percentages of 28.44 and 38.40 also encouraged its growth. It developed to some extent with 18.83 per cent. of moisture, but in the normal meal containing but 11.52 per cent. the conditions were by no means favorable to its development. In all of the tests there was practically no increased mould development after forty-two days, and this may be accounted for by the fact that after that period the moisture content varied from 6.90 to 8.69 per cent., showing that, not only had all the added moisture been lost, but also a part of that originally in the meal. This low moisture content while not entirely checking the mould, nevertheless did not encourage its growth, as we have already seen

Changes in Fat Content.

Inasmuch as the amounts of moisture contained in the different tests were so variable, the following table has been prepared on the basis of water-free material, thus affording an opportunity of studying the changes in the fat of the different tests on a comparable basis.

CHANGES IN FAT CONTENT.

WATER-FREE BASIS.

TEST.	Length of period.	Weight of cornmeal and water taken.	Amount of water at beginning.	FAT. WEIGHT. Beginning.	FAT. WEIGHT. End.	FAT. WEIGHT. Loss.	FAT. PERCENTAGE. Beginning.	FAT. PERCENTAGE. End.	FAT. PERCENTAGE. Loss.	FAT. PERCENTAGE. Percentage loss.
	Days.	gms.	%	mgms.	mgms.	mgms.	%	%	%	%
Period I	21	....	....	....	....	....	....	....	....	....
1— 2	....	2.0000	11.52	87.3	79.0	8 3	4.36	3.99	0.37	8.5
11—12	....	2.1801	18.83	95.1	72.5	22.6	4.36	3.62	0.74	17.0
22—23	....	2.3726	25.42	103.5	75.5	28.0	4.36	3.12	1.24	28.4
32	....	2.4729	28.44	107.9	71.2	36.7	4.36	3.29	1.07	24.5
33	....	3.5249	49.80	153.8	78.3	75.5	4.36	2.81	1.55	35.5
42—43	....	2.8697	38.40	125.3	75.4	49.9	4.36	3.08	1.28	29.4
Period II	42	....	....	....	....	....	....	....	....	....
3— 4	....	2.0000	11.52	87.3	72.9	14.4	4.36	3.78	0.58	13.3
13—14	....	2.2169	20.18	96.7	63.3	33.4	4.36	3.27	1.09	25.0
24—25	....	2.3683	25.27	103.3	43.1	60.2	4.36	2.23	2.13	48.9
34—35	....	2.4570	27.96	107.2	58.4	48.8	4.36	3.01	1.35	31.0
44—45	....	2.8753	38.50	125.5	54.1	71.4	4.36	2.79	1.57	36.2
Period III	56	....	....	....	....	....	....	....	....	....
5— 6	....	2.0000	11.52	87.3	77.6	9.7	4.36	4.03	0.33	7.6
15—16	....	2.1753	18.65	94.9	71.4	23.5	4.36	3.70	0.66	15.1
26—27	....	2.3862	25.85	104.1	52.0	52.1	4.36	2.73	1.63	37.4
36—37	....	2.4843	28.76	108.4	60.4	48.0	4.36	3.14	1.22	28.0
46—47	....	2.8739	38.48	125.5	59.6	65.9	4.36	3.12	1.24	28.4
Period IV	77	....	....	....	....	....	....	....	....	....
7— 8	....	2.0000	11.52	87.3	71.4	15.9	4.36	3.71	0.65	14.9
17—18	....	2.1758	18.67	94.9	67.2	27.7	4.36	3.48	0.88	20.2
28—29	....	2.3810	25.69	103.9	54.7	49.2	4.36	2.85	1.51	34.6
38—39	....	2.4966	29.14	108.9	56.4	52.5	4.36	2.93	1.43	32.8
48—49	....	2.8916	38.81	126.2	54.2	72.0	4.36	2.83	1.53	35.1

The above table shows very striking losses of fat in every case, although in some cases a prolonged period did not occasion a further loss. In the first period of twenty-one days the losses varied from 8.5 to 35.5 per cent., the smallest loss appearing in the normal meal, and a greater loss being shown, in all but one test, as the moisture content was increased. In the presence of 49.80 per cent. moisture the mould destroyed 35.5 per cent. of the fat. In the second period of forty-two days an increased loss of fat is shown in every case, ranging from 13.3 to 48.9 per cent., but the test containing 25.27 per cent. of moisture shows the greatest loss. In the third period of fifty-six days the losses, while very pronounced, are less than those shown in the second period, and range from 7.6 to 37.4 per cent. The test containing 25.85 per cent. of moisture still leads, and the other tests follow in the same order as in the second period. In the fourth period of seventy-seven days the losses range from 14.9 to 35.1 per cent. In this period the losses in tests 7–8 and 38–39 are the greatest shown during the experiment for moisture contents of 11.52 and 27.96—29.14 per cent., respectively.

Averaging the results obtained in the four periods on tests containing approximately the same amounts of moisture, we obtain the following figures:

	Average.	Loss.
Tests 1–8, with 11.52 % water	11.52	11.1 %
" 11–18, " 18.65–20.18 % water	19.08	19.3 "
" 22–29, " 25.27–25.85 " "	25.47	37.3 "
" 32–39, " 27.96–29.14 " "	28.72	39.1 "
" 42–49, " 38.40–38.81 " "	38.41	32.3 "

These figures show that during periods of from three to eleven weeks the losses of fat ranged from 11.1 to 37.3 per cent., the smallest loss appearing in the normal meal and the largest in the meal containing 25.47 per cent. of moisture. In other words, it is shown by these experiments that in corn meal containing but 11.52 per cent. of moisture the losses of fat are comparatively slight, but that when the moisture content is raised above 18 per cent. serious losses of fat follow, the mould appearing to show its greatest activity in a medium containing about 25 per cent. of moisture. These results are strictly in accord with those of Spieckermann and Bremer, already referred to, and seem to establish the fact that, under the proper moisture conditions, *Penicillium glaucum* can, and does, cause very

marked losses in the fat of corn meal. The question of the nature of the changes which the fat undergoes will be considered in a later portion of this report.

CHANGES IN PROTEIN CONTENT.

WATER-FREE BASIS.

TEST.	Amount of water at beginning.	PROTEIN.				TEST.	Amount of water at beginning	PROTEIN.			
		Beginning.	End.	Loss.	Percentage loss.			Beginning.	End.	Loss.	Percentage loss.
Period I.	%	%	%	%	%	Period III.	%	%	%	%	%
1— 2.........	11.52	10.81	10.77	0.04	0.4	5— 6........	11.51	10.81	10.52	0.29	2.7
11—12	18.83	10.81	10.74	0.07	0.7	15—16.........	18.65	10.81	10.47	0.34	3.1
22—23.........	25.42	10.81	10.81	0.00	0.0	26—27........	25.85	10.81	10.56	0.25	2.3
32.........	28.44	10.81	10.59	0.22	2.0	36—37.........	28.76	10.81	10.36	0.45	4.2
42—43.........	38.40	10.81	10.47	0.34	3.1	46—47........	38.48	10.81	10.12	0.69	6.4
Period II.						Period IV.					
3— 4.........	11.52	10.81	10.66	0.15	1.4	7— 8........	11.52	10.81	10.49	0.32	3.0
13—14.........	20.18	10.81	10.53	0.28	2.6	17—18	18.67	10.81	10.53	0.28	2.6
24—25.........	25.27	10.81	10.58	0.23	2.1	28—29.........	25.69	10.81	10.59	0.22	2.0
34—35.........	27.96	10.81	10.43	0.38	3 5	38—39........	29.14	10.81	10.42	0.39	3.6
44—45.........	38.50	10.81	10.29	0.52	4.8	48—49.........	38.81	10.81	10.35	0.46	4.3

As will be seen from the table, the losses in protein were very slight, the greatest loss being 6.4 per cent. Still, with two exceptions, the losses in each period increased with the increase of moisture. In period I. the losses range from nothing to 3.1; in period II. from 1.4 to 4.8; in period III. from 2.7 to 6.4, and in period IV. from 2.0 to 4.3 per cent. The losses also increased with the duration of the period, except in period IV., where they were practically identical with those shown in period II. The average losses for the four periods with the different percentages of moisture were 1.9, 2.3, 1.6, 3.3 and 4.7 per cent., results somewhat at variance with those secured on the fat, for whereas in the case of fat the greatest loss was found in the presence of 25.47 per cent. of moisture; in the case of protein the loss with that per cent. of moisture was the lowest. These results,

however, in general, confirm those of Spieckermann and Bremer, already referred to, namely, that the greatest loss in fat occurs with a moisture content of from 25 to 30 per cent., while the losses in protein increase slightly as the moisture content is raised. Thus we see that *P. glaucum* fails to encourage a loss of proteids, and this fact is taken advantage of by the manufacturers of Roquefort cheese, who employ this mould during the process of ripening to consume the acids produced by the lactic acid bacteria and to retard the development of the albumin-degrading organisms.

Series II.

In this series of experiments six portions of 100 grams each of the corn meal were weighed into tall Erlenmeyer flasks and varying amounts of water added. Five of these portions were sterilized and inoculated with pure cultures of *Penicillium glaucum,* and the flasks then plugged with sterilized absorbent cotton. The sixth portion was not sterilized, as in this portion it was planned to study the spontaneous development of mould in the presence of excessive moisture. The flasks were inoculated on November 21st, and remained undisturbed until the end of the experiment, on January 16th, a period of eight weeks. The following tabulation shows the scheme of the experiment and the quantities of water added to the different tests:

No. of Test.	Water. added. gms.	Per Cent. of Water.	
1	0	11.52	inoculated.
2	10	19.63	"
3	20	26.39	"
4	25	29.33	"
5	45	39.06	"
6	20	26.39	not inoculated.

Development of Mould.

In less than one week mould appeared in tests 5 and 6, and in a few days later was visible in all the tests except 1 and 2. Three weeks after the beginning of the experiment a pinkish mould developed in test 5, which was accompanied by a deposition of globules of fat on the sides of the flask. A later microscopical examination

of this mould showed it to be one of the genus *Mucor,* although every precaution had been taken to eliminate all moulds but *Penicillium* from the test. However, its presence in no way detracts from the results of the test, as, although the experiment was planned to study *Penicillium* in particular, the effects of the more common moulds have been shown to be so similar in certain respects that the presence of this foreign mould probably had little influence in changing the general results. In test 6, where mould was allowed to develop spontaneously in the presence of about 26 per cent. of water, there was a rapid and vigorous growth of mould, which soon permeated the whole material, so that at the end of the experiment it was a wet and slimy mass and had contracted to about one-half of its original bulk. Cultures were made from this material on potato, and *Penicillium glaucum* and an unidentified bacterial growth were observed. As this test was not examined microscopically until the end of the experiment, in order to preserve it from external contamination, it is possible that other moulds may have developed in the meantime, taken their course and been swallowed up by the excessive growth of *Penicillium.* At any rate the action of this test clearly showed that, given the proper moisture conditions, moulds will develop spontaneously in corn meal, and seems to point definitely to the conclusion that, in corn meal at least, their spores are present awaiting suitable moisture conditions for their development.

At the end of the experiment the meals of the different tests were weighed, dried and reground for analysis, and water, fat, protein, albuminoids, fiber, ash and carbohydrates determined therein. The results of these analyses are shown in the following table. In the further consideration, however, of these figures, they will be studied on the basis of the actual weight of the different ingredients, in order to furnish a more equable basis of comparison.

ANALYSIS OF MEALS AT BEGINNING AND END OF EXPERIMENT.

TEST.	Dry Matter.	Water.	Fat.	Fiber.	Ash.	Carbohydrates.	Protein.	Albuminoids.	Amides.
At Beginning.	%	%	%	%	%	%	%	%	%
1	88.48	11.52	3.86	1.59	1 53	71.94	9 56	9.45	0.11
2	80.37	19.63	3.51	1.44	1.39	65.34	8.69	8.58	0.11
3	73.61	26.39	3.21	1.32	1.27	59.85	7.96	7.86	0.10
4	70.67	29.33	3.08	1.27	1.22	57.46	7.64	7.55	0.09
5	60.94	39.06	2.66	1.10	1.05	49.54	6.59	6.50	0.09
6	73.61	26.39	3.21	1.32	1.27	59.85	7.96	7.86	0.10
At End.									
1	88.71	11.29	3.73	1.60	1 51	72.46	9.41	9.24	0.17
2	80.48	19.52	3.08	1.45	1.36	66.00	8.59	8.39	0.20
3	72.92	27.08	1.31	1.44	1.29	61.03	7.85	7.59	0.26
4	69.45	30.55	1.18	1.32	1.17	58.26	7.52	7.45	0.07
5	44 22	55.78	0.79	1.88	1.06	34.14	6.35	6.19	0.16
6	23.18	76.82	0.62	2 36	1.16	13.31	5.73	3.53	2.20

Changes in Moisture and Dry Matter.

As stated previously in this report, no attempt was made to preserve the same moisture conditions throughout the experiment, and there were losses of moisture in every case except test 6, although these losses were much less than in the previous series, because of the large amount of material used and the relatively small surface exposed to the direct action of the air. The following tabulation shows the changes in moisture and dry matter during the experiment:

Test.	WATER At Beginning. gms.	At End. gms.	Gain or Loss. gms.	DRY MATTER At Beginning. gms.	At End. gms.	Gain or Loss. gms.	Percentage Gain or Loss. %
1......	11.52	7.89	— 3.63	88.48	88.71	+ 0.23	+ 0.3
2......	21.62	9.99	—11.63	88.48	88.61	+ 0.13	+ 0.1
3......	31.72	16.05	—15.67	88.48	87.65	— 0.83	— 0.9
4......	36.72	20.55	—16.17	88.48	86.95	— 1.53	— 1.7
5......	56.72	49.76	— 6.96	88.48	64.24	—24.24	—27.4
6......	31.72	43.54	+11.82	88.48	27.86	—60.62	—68.5

No conclusions can be drawn from the changes in the amount of water present, for the reasons above stated, but it is a striking fact that in test 6, in spite of the opportunity given for the escape of moisture, there was an increase of water of 11.82 gms., or 37.3 per cent. The dry matter of tests 1 and 2 suffered practically no change, slight gains of 0.23 and 0.13 gms., respectively, being shown. In the other three tests which can be compared there was a loss in each case varying from 0.83 to 24.24 gms., or 0.9 to 27.4 per cent., the loss increasing as the moisture content became greater. In test 6 the spontaneous growth of mould and bacteria caused a loss of 60.62 gms., or 68.5 per cent., of the dry matter of the meal.

Changes in Fat.

Test.	At Beginning. gms.	At End. gms.	Loss. gms.	Percentage Loss. %
1......................	3.86	3.72	0.14	3.5
2......................	3.86	3.39	0.47	12.2
3......................	3.86	1.58	2.28	59.1
4......................	3.86	1.47	2.39	61.9
5......................	3.86	1.14	2.72	70.4
6......................	3.86	0.75	3.11	80.6

With the exception of test 1, there was a very decided loss of fat in every case. These losses varied from 0.14 to 2.72 gms., or 3.5 to 70.4 per cent., and increased as the quantity of moisture was increased; in test 6 there was a loss of fat of 80.6 per cent. These results are practically in accord with those reported in series I., namely, that with the moisture less than 18 per cent. the losses are comparatively small, and that they reach their maximum with a moisture content of from 25 to 30 per cent. The tests 5 and 6 are

not strictly comparable with the other four tests, because of the slightly different conditions, *Mucor* having developed in the one and a bacterium in the other. The losses in fat due to the action of moulds are very striking and indicate clearly the great deterioration corn meal is liable to suffer when excessive moisture conditions are allowed to prevail. It must be remembered, too, that these losses cannot be attributed alone to the mould spores *added,* for in test 6 there was no inoculation with *Penicillium,* yet in that test, simply by increasing the moisture from 11.52 to 26.39 per cent., both *Penicillium* and bacteria developed spontaneously, and caused a loss of 3.11 gms. of fat, or 80.6 per cent. Test 3 and test 6 are strictly comparable, for the mosture conditions were exactly the same; in the former there was a loss of 2.28 gms. of fat, or 59.1 per cent., while in the latter the loss was 3.11 gms., or 80.6 per cent. As the only difference in the two tests was the spontaneous development of bacteria in the latter, the difference, 0.83 gms., or 21.5 per cent., can be attributed directly to the action of the bacteria.

Maize oil consists chiefly of olein and linolin, with small quantities of stearin, lecithin and cholesterin. (See page 124.) The alcohol, cholesterin, occurs in combination with fatty acids, forming an ester similar to a glyceride. The lecithin, a complex, nitrogenous, fatty substance, is easily decomposed into stearic acid, glycerin-phosphoric acid and cholin, or neurin. However, inasmuch as the olein and linolin make up about 93 per cent. of the total fat, the large losses above noted must be looked for in these compounds. Olein and linolin are the glycerides of oleic and linoleic acids, respectively, and may be decomposed in various ways into their fatty acids and glycerin. It has been found that this splitting up of fats may be occasioned by the action of the enzyme, steapsin, or lipase, a normal secretion of the pancreatic juice. Gérard, as stated previously, has separated from *Penicillium glaucum* an active substance having all the properties of lipase. We can, therefore, understand the reason for the large losses of fat in the presence of this mould.

These losses of fat have an important practical significance to the miller, especially as shown in test 2, where there was insufficient moisture to render the growth of the mould visible to the unaided eye. Still, it was shown in this test that there was a loss of 12.2 per cent. of fat, a comparatively large loss, which might, and probably would, occur without arousing the suspicion of the miller, and simply due to an increase of 10 per cent. in the moisture content of

the meal, the microscope revealing the fact that the mould was present in the meal, but not sufficiently developed to be visible to the naked eye.

Changes in Proteids.

	TOTAL PROTEIDS			ALBUMINOIDS			AMIDES		
Test.	At Beginning. gms.	At End. gms.	Gain or Loss. gms.	At Beginning. gms.	At End. gms.	Gain or Loss. gms.	At Beginning. gms.	At End. gms.	Gain or Loss. gms.
1......	9.56	9.41	—0.15	9.45	9.24	—0.21	0.11	0.17	+0.06
2......	9.56	9.46	—0.10	9.45	9.24	—0.21	0.11	0.22	+0.11
3......	9.56	9.43	—0.13	9.45	9.12	—0.33	0.11	0.31	+0.20
4......	9.56	9.42	—0.14	9.45	9.33	—0.12	0.11	0.09	—0.02
5......	9.56	9.21	—0.35	9.45	8.99	—0.46	0.11	0.22	+0.11
6......	9.56	6.88	—2.68	9.45	4.24	—5.21	0.11	2.64	+2.53

Total proteids and albuminoids were determined in the meal, and the amides calculated by difference. The losses in both total proteids and albuminoids were very trifling in all the tests except No. 6. The losses of total proteids vary from 0.10 to 0.15 gms. where *Penicillium* alone was present; the addition of *Mucor* raised the loss to 0.35 gms., while the action of bacteria and moulds, in test 6, occasioned a loss of 2.68 gms., or 28 per cent. The losses in tests 1 to 5 were equivalent to but from 0.016 to 0.056 gms. of nitrogen, almost within the range of experimental error, so that it may be safely concluded from this experiment that *Penicillium glaucum* has practically no effect on the total proteids of corn meal; *Mucor* seems to have a very slightly injurious effect, but in a period of eight weeks the loss caused by this mould was but 0.21 gms., or 2.2 per cent. The unidentified bacterial growth in test 6, however, exercised a very injurious effect on the proteid compounds of the meal. It was noticed, on the completion of the experiment, that the material in test 6 gave forth a strong ammoniacal odor, and the analysis of the residual material shows the magnitude of the loss thus occasioned by the partial conversion of the organic proteid material into volatile ammoniacal compounds. The determination of the albuminoids likewise shows that this large loss of protein was produced at the expense of the valuable albuminoids, for while the loss of total proteids was but 2.68 gms., the loss of true albuminoids was 5.21 gms., and the

amido compounds, which, from a feeding standpoint, are comparatively much inferior, showed a corresponding gain of 2.53 gms.

Albert[21] has shown in experiments with green pressed fodder, prepared from meadow grass, that the ferments consume a large amount of the albuminoids, originally present, and decompose them into amide compounds, ammonia derivatives, and even ammonia, the amount of these matters eliminated ranging from 13 to 31 per cent. of the total proteids present. Julius Kühn,[22] in preparing soured green maize, noted a loss of about 40 per cent. in total proteids, while in another experiment with beet slices the loss was from 18 to 62 per cent., and O. Kellner[22] found with soured beet leaves a loss of even 68 per cent.

Thus it is seen that the results harmonize with those of other workers, for it has been shown repeatedly that, even under very severe adverse conditions, the losses of protein from the action of moulds are very insignificant, while, on the other hand, many forms of bacterial growth not only cause a loss of the more valuable proteid compounds by conversion to ammonia, which is lost by volatilization, but also by converting a part of the albuminoids into inferior, unassimilable amido compounds.

Changes in Ash and Fiber.

	ASH			FIBER		
Test.	At Beginning. gms.	At End. gms.	Gain or Loss. gms.	At Beginning. gms.	At End. gms.	Gain or Loss. gms.
1	1.53	1.51	—0.02	1.59	1.60	+0.01
2	1.53	1.50	—0.03	1.59	1.60	+0.01
3	1.53	1.55	+0.02	1.59	1.73	+0.14
4	1.53	1.53	0.00	1.59	1.65	+0.06
5	1.53	1.47	—0.06	1.59	2.73	+1.14
6	1.53	1.40	—0.13	1.59	2.83	+1.24

The changes in the content of ash were very small, ranging from a gain of 0.02 gms. to a loss of 0.13 gms. The greatest loss was again shown in test 6, while in the tests inoculated with *Penicillium* it was shown that that mould had practically no deleterious effect on

[21] Lafar's Technical Mycology, English ed., Vol. 1, p. 263.
[22] Lafar's Technical Mycology, English ed., Vol. 1, p. 264.

the ash of corn meal; the effect of the bacteria in test 6 was also very slight. The mineral ingredients of the ash occupy an important position in the nutriment of the lower organisms, for while the quantities utilized by them are very small, even these small amounts have been shown to be quite essential for their proper growth. For the Eumycetes in particular, to which *Penicillium* belongs, it has been shown, by a long series of experiments by different workers, that, in addition to carbon, hydrogen, oxygen and nitrogen, sulphur, phosphorus, potassium (or rubidium), magnesium and iron are indispensable for their structure and complete development.[23] Nevertheless, while there has doubtless been considerable use made of the mineral elements of the meal by these organisms, the results above tabulated would seem to indicate that little, if any, of the ash constituents are by them rendered volatile, and thus lost to the meal.

Likewise in the case of fiber, the changes in the first four tests were very insignificant, varying from 0.01 to 0.14 gms. increase. In tests 5 and 6, however, there are very marked increases, namely, 1.14 and 1.24 gms., or 71.7 and 78 per cent., respectively. It is somewhat difficult to account for these gains in fiber, for, as will be seen later, the losses in carbohydrates other than fiber in these tests were very great. The Weende method for crude fiber, which was used to secure these results, is confessedly unsatisfactory, and it was observed, in conducting the analyses of these two tests, that the filtration was extremely slow, the residue not acted upon by the dilute acid and alkali being of a decidedly mucilaginous nature. Still, while this made the process of washing very difficult, the filtration requiring nearly two days in each case, it would but in part account for the extremely high results. In the examination of the cell membrane of *P. glaucum* and *Mucor mucedo* by C. van Wisselingh[24] the presence of chitin was invariably detected. E. Winterstein[25] found 3.3 per cent. of nitrogen in the cell walls of *P. glaucum.* As stated before, according to Lafar,[26] there is at present no known instance where cellulose and chitin occur simultaneously in the cell membrane of a fungus. Further, *P. glaucum* has been found incapable of dissolving true cellulose, though it can attack the so-called central lamellæ, therefore secreting a pectin-dissolving enzyme. It has been shown,

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[23] Lafar, Vol. 2, pt. 1, p. 52.
[24] Lafar, Vol. 2, pt. 1, p. 37.
[25] Lafar, Vol. 2, pt. 1, p. 34.
[26] Lafar, Vol. 2, pt. 1, p. 37.

however, by Mangin[27] that this intermediate intercellular substance does not consist of pectose, as stated by Kolb, but of calcium pectate. The results with the tests 1–4 therefore confirm the inability of *P. glaucum* to act upon cellulose, and indirectly show the absence of cellulose in its cell-walls. The increase in fiber in tests 5 and 6 cannot be explained with our present knowledge; whether these gains are due to imperfection in the methods of analysis, or to some form of activity of the moulds and bacteria, must be determined by future experiments.

Changes in Nitrogen-Free Extract.

Test.	At Beginning. gms.	At End. gms.	Gain or Loss. gms.	Percentage Gain or Loss. %
1	72.09	72.47	+ 0.38	+ 0.5
2	72.09	72.66	+ 0.57	+ 0.8
3	72.09	73.36	+ 1.27	+ 1.8
4	72.09	72.94	+ 0.85	+ 1.2
5	72.09	49.63	—22.46	—31.2
6	72.09	16.00	—56.09	—77.8

The changes in the nitrogen-free extract in the first four tests were quite slight, varying from 0.38 to 1.27 gms., or 0.5 to 1.8 per cent., increase. When it is remembered that the nitrogen-free extract was obtained by difference, and therefore includes all the errors of analysis, the small increased content of these compounds appears very insignificant. Nevertheless, we know that *Penicillium glaucum* and many other moulds and bacteria have the power of secreting enzymes which attack the carbohydrates. (See page 127.)

It is evident, therefore, that *P. glaucum* can effect very great changes in the carbohydrate compounds by means of the enzymes, which it secretes. The results above tabulated would seem to indicate, however, that even though these changes may be great, the total amount of carbohydrates remains practically unchanged. It was intended to make determinations of starch, sugar and pentosans in each of the tests, but the smallness of the sample and pressure of other duties prevented these analyses. It is hoped, however, in a future prosecution of these studies to ascertain all the changes effected in this class of food compounds by the mould under consideration.

In tests 5 and 6, instead of a gain in carbohydrates as in the other tests, there were large losses, amounting to 22.46 gms., or 31.2 per cent., in test 5, and 56.09 gms., or 77.8 per cent., in test 6. In test

[27] Lafar, Vol. 1, p. 197.

5, as previously pointed out, one of the *Mucorinæ* was present; the loss in this test, while probably in part attributable to the large quantity of moisture present, is also in part probably due to the action of the *Mucor* present. The large losses in test 6, likewise, are probably attributable to the action of the unidentified bacterial growth. By analogy it would seem that this great decrease in carbohydrates was due to the cytase present, the loss chiefly taking the form of carbon-dioxid, and possibly marsh gas. This is mere surmise, however, and further study will be necessary to determine the question with any certainty.

Conclusions.

The experiments above reported would seem to warrant the following conclusions:

1. The spores of *Penicillium glaucum* and certain bacteria are generally present in commercial corn meal, and will develop spontaneously under proper conditions of moisture.

2. A moisture content of from 25.42 to 38.40 per cent. is favorable to the growth of mould, the maximum growth being obtained at the lower figure. Not only does an excess of moisture cause an increased growth of mould, but with this increase of mould also appears a large increase of moisture, in one case amounting to 68.5 per cent.

3. The action of *P. glaucum* on the food compounds of the meal is probably due to the enzymes it secretes.

4. The losses in fat varied from 3.5 to 70.4 per cent., according to the amount of water present, reaching the maximum with a moisture content of from 25 to 29 per cent. With a moisture content of 21 per cent., there was a development of mould, only visible microscopically, and yet causing a loss of over 12 per cent. of fat.

5. The losses in total proteids were small, but where bacteria were present this loss was very large. Not only were total proteids lost, but the chief part of this loss fell on the albuminoids, a part of the latter being converted into less valuable amido-compounds, and other portions being volatilized as ammonia.

6. The changes in total ash were trifling.

7. The changes in fiber were small where *P. glaucum* alone was used, but in the presence of *Mucor* and the bacterial growth an increase of fiber from 72 to 78 per cent. was observed.

8. *Penicillium glaucum* had practically no effect on the *total* nitrogen-free extract, but *Mucor* and the bacteria caused very great losses.

INVESTIGATIONS RELATIVE TO THE USE OF NITROGENOUS MATERIALS.

BY EDWARD B. VOORHEES.

The progress of this work reported in the annual publications of this Station for the preceding four years[1] has been uninterrupted. The same methods have been pursued in the more recent experiments, and the results of these are a distinct addition to the experience already accumulated. They are a distinct addition in that they were obtained under changing conditions.

When the experiments were begun the soil conditions were uniform. The amount of nitrogen present in each cylinder was the same, and the differences as they were expressed by the first crop were due solely to the different treatment in the application of manure or fertilizer. As time progressed, however, the soil itself began to show differences. The crop no longer showed the differences in the system of manuring for that season alone, but it expressed the accumulated differences of several seasons. The application of manure in some cases, and the application of mineral fertilizers alone in others, or the application of both together, gradually caused each soil to assume a character of its own. As time progressed the divergence became more emphasized. The chemical, physical and biological character of these soils were all effected in an unequal degree, and for this reason these experiments acquired an additional interest. And this interest is not merely theoretical. Practical agriculture may draw an instructive lesson from these investigations. It may see for itself the advantages or disadvantages of different systems of manuring. It may see, likewise, that enormous losses of soil nitrogen are bound to take place where exhaustive non-leguminous crops are grown continuously for a series of years. Different soils may be effected differently in this respect, nevertheless all of them must suffer greater or slighter losses of nitrogen.

The method of treatment has been outlined in previous reports. It includes the study of the availability of nitrogen in various nitrogenous materials, and affords a means for determining their relative value from the economic standpoint. It thus enables the farmer

[1] N. J. St. Rep's, 1899, p. 97; 1900, p. 88; 1901, p. 144; 1902, p. 133.

to decide for himself what forms of nitrogen are the most desirable under given conditions. The study has also been continued of the composition of cow manure and of the changes in its composition due to leaching. The collection, treatment and analysis of the manure samples were carried out as heretofore.

THE COMPOSITION OF THE SOLID, AND OF SOLID AND LIQUID PORTIONS OF COW MANURE, FRESH.

The fresh manures collected in the customary manner had the following composition:

Fresh Manure, Solid.

	1902.	Average of Five Other Samples.
	%	%
Water	83.488	85.055
Ash	2.410	2.290
Organic matter	14.102	12.255
Nitrogen (total)	0.384	0.338
" soluble in H_2O	0.048	0.069
" as nitrates	0.000	0.008
" as ammonia	0.035	0.020
" as soluble organic	0.013	0.041
" as insoluble organic	0.336	0.269
Phosphoric acid	0.394	0.351
Potash	0.224	0.203

The composition of this sample does not vary greatly from that of other samples analyzed previously. It was slightly drier than most of those, and was therefore proportionately richer in total nitrogen than any of the others. On the other hand, it contained less water-soluble nitrogen and less soluble organic nitrogen. It was also richer in ash, in phosphoric acid and in potash than the average of the other five.

Fresh Manure, Solid and Liquid.

	1902.	Average of Five Other Samples.
	%	%
Water	90.801	86.272
Ash	1.734	2.223
Organic matter	7.465	11.505
Nitrogen (total)	0.494	0.449
" water-soluble	0.320	0.213
" as nitrate	0.000	0.009
" as ammonia	0.046	0.126
" as soluble organic	0.274	0.083
" as insoluble organic	0.174	0.232
Phosphoric acid	0.219	0.329
Potash	0.376	0.426

This sample contained more water than the others, and was therefore proportionately poorer in ash and in organic matter. It was, at the same time, richer in total and in water-soluble nitrogen. The difference was undoubtedly due to the greater proportion in this particular sample of liquid manure, which, as is well known, is richer in soluble organic nitrogen. The proportionate amounts of phosphoric acid and of potash were smaller, as was to be expected. It is interesting to note that in the other five samples there was contained, on the average, .213 per cent. of water-soluble nitrogen, equivalent to 47.4 per cent. of the total nitrogen, while in the sample used in 1902 there were .320 per cent. of water-soluble nitrogen, equivalent to 64.7 per cent. of the total nitrogen. The soluble organic consisted in the latter of .046 per cent. of ammonia nitrogen and of .274 per cent. of soluble organic nitrogen, and in the other samples it consisted, on the average, of .009 per cent. of nitrate nitrogen, .126 per cent. of ammonia nitrogen and of .083 per cent. of soluble organic nitrogen.

Comparing the solid, and the solid and liquid portions in the samples of 1902, it will be noticed that in the solid portion there are .048 per cent. of water-soluble nitrogen out of .384 per cent. of total nitrogen. In other words, the solid manure contains .384 per cent. of total nitrogen, and that only 12.5 per cent. of this material is soluble in water. In the case of the solid and liquid portion there are .494 per cent. of total nitrogen, and of this amount 64.7 per cent. is soluble in water. The amounts of ammonia do not differ in the two to any marked extent, but there is a very considerable difference in the case of the water-soluble organic nitrogen. In the solid portion this is slight, only .013 per cent., while in the solid and liquid portion it amounts to .274 per cent. The solid, fresh, contains, on the other hand, .336 per cent. of insoluble organic, the corres-

ponding amount in the solid and liquid portion being only .174 per cent. The solid portion is also richer in phosphoric acid than the solid and liquid portion, but is poorer in potash than the latter.

COMPOSITION OF THE MANURES ON THE WATER-FREE BASIS.

Solid, Fresh.

	Sample of 1902. %	Average of Five Other Samples. %
Ash	14.530	15.324
Organic matter	85.470	84.676
Nitrogen (total)	2.325	2.263
" water-soluble	0.291	0.460
" as nitrate	0.000	0.055
" as ammonia	0.212	0.134
" as soluble organic	0.079	0.271
" as insoluble organic	2.035	1.802
Phosphoric acid	2.386	2.348
Potash	1.357	1.485

The sample for 1902 is richer in organic matter and poorer in ash than the average of the other samples. It is richer in total nitrogen and poorer in water-soluble nitrogen compounds. Most of the latter are present here as ammonia or its compounds, while in the other samples the greater proportion occurs as soluble organic nitrogen. That would merely indicate that in the sample for 1902 the decomposition of the hippuric acid and urea were farther advanced. This sample is also richer in insoluble organic nitrogen, poorer in potash and slightly richer in phosphoric acid than the average of the other samples. The variations, on the whole, are not great, and the samples collected yearly for six successive years are fairly uniform in composition.

Solid and Liquid, Fresh.

	Sample of 1902. %	Average of Five Other Samples. %
Ash	18.850	16.824
Organic matter	81.150	83.176
Nitrogen (total)	5.370	3.254
" water-soluble	3.479	1.555
" as nitrate	0.000	0.053
" as ammonia	0.500	0.903
" as soluble organic	2.979	0.599
" as insoluble organic	1.891	1.699
Phosphoric acid	2.381	2.396
Potash	4.087	3.453

The sample of 1902 contains a proportionately greater amount of ash and a correspondingly slighter amount of organic matter. It also contains more total and more water-soluble organic nitrogen than the average of the other samples. The difference is particularly pronounced in the case of the water-soluble nitrogen, of which there is almost double the amount in the sample of 1902. This water-soluble nitrogen consists mostly of organic forms, and it will be noted that the sample of 1902 contains 2.979 per cent. of the latter, as against .599 per cent. contained in the average of the other samples. The amount of phosphoric acid in the sample of 1902 is practically the same as in the average of the other samples, while the amount of potash is somewhat greater. The greater proportionate amounts of both soluble nitrogen and of potash are due, as was already pointed out, to the greater proportion in this sample of liquid manure, which, as is well known, contains a large proportion of nitrogen and of potash.

THE COMPOSITION OF THE SOLID, AND OF THE SOLID AND LIQUID PORTIONS OF COW MANURE, LEACHED.

The fresh manures were exposed to the leaching action of rain, in the customary manner, from May 28th until July 29th. The composition of the manures, both before and after leaching, is given below. During that time the 100 pounds of manure were reduced in each case to sixty-two pounds.

COMPOSITION OF MANURES ON WATER-FREE BASIS.

	Solid, Fresh. A. %	Solid and Liquid, Fresh. B. %	Solid, Leached. C. %	Solid and Liquid, Leached. D. %
Ash	19.490	21.765	24.923	20.547
Organic matter	80.510	78.235	75.077	79.453
Nitrogen (total)	2.423	3.685	2.278	2.753
" water-soluble	0.486	1.850	0.339	0.985
" as nitrate	0.000	0.000	0.000	0.000
" as ammonia	0.253	1.495	0.213	0.073
" as soluble organic	0.233	0.355	0.126	0.912
" as insoluble organic	1.937	1.835	1.939	1.768
Phosphoric acid	2.423	3.183	2.372	3.100
Potash	1.771	6.289	1.649	4.093

Losses Sustained by Leaching.

	62 lbs. of C. Contain — %	Loss. %	62 lbs. of D. Contain— %	Loss. %
Ash	15.452	4.038	12.739	9.026
Organic matter	46.548	33.962	49.261	28.974
Nitrogen (total)	1.412	1.011	1.707	1.978
" water-soluble	0.210	0.276	0.611	1.239
" as nitrate	0.000	0.000	0.000	0.000
" as ammonia	0.132	0.121	0.045	1.450
" as soluble organic	0.078	0.155	0.566	0.211
" as insoluble organic	1.202	0.735	1.096	0.739
Phosphoric acid	1.471	0.952	1.922	1.261
Potash	1.022	0.749	2.538	3.751

These tabulations show that the dry matter of the leached manure was poorer in nitrogen, phosphoric acid and potash than the corresponding fresh manures. Thus the dry matter of the solid, fresh, contained 2.423 per cent. of total nitrogen, while after an exposure of sixty-two days it contained only 2.278 per cent.; similarly with the solid and liquid portions there was a reduction from 3.685 per cent. to 2.753 per cent. The greatest proportionate loss took place in the water-soluble nitrogen, which was reduced in the solid portion from .486 per cent. to .339 per cent., and in the solid and liquid portion from 1.850 per cent. to .985 per cent. A very great loss of ammonia occurred in the case of the solid and liquid portion, where it was reduced from 1.495 per cent. to .073 per cent. Considerable losses also occurred here in the case of the potash, which was reduced here from 6.289 per cent. to 4.093 per cent. The content of phosphoric acid in either the solid or solid and liquid portion was not changed to as great an extent. All these facts show again that the losses fall most heavily in the soluble, and therefore valuable portions of the manure. To show more clearly the extent of such losses, the proportionate amount lost both in the solid and the solid and liquid portions are given, as well as the average loss in five similar samples reported previously.

Proportionate Loss by Leaching.

	SAMPLES FOR 1902.		AVERAGE OF FIVE OTHER SAMPLES.	
	Solid, Fresh.	Solid and Liquid, Fresh.	Solid, Fresh.	Solid and Liquid, Fresh.
	%	%	%	%
Ash	20	41	33.6	39.3
Organic matter	42	37	37.6	40.7
Nitrogen (total)	42	54	38.4	52.6
" soluble in H_2O	57	67	....	....
" as nitrate	..	..	....	....
" as ammonia	48	97	....	....
" as soluble organic	67	+59	....	....
" as insoluble organic	38	40	....	....
Phosphoric acid	39	40	46.8	48.0
Potash	42	60	44.4	57.6

It will be noted that there was more nitrogen and more potash lost from the solid and liquid portion than there was from the solid portion—a phenomenon, already explained above. The average of the other sample shows a similar relation. In the case of phosphoric acid the differences are not as great, owing to the slighter solubility of the phosphoric acid. In all cases, however, the losses were very considerable, amounting in some instances to more than half of the plant-food originally present. Thus, in the case of the solid, fresh, there was a loss of 57 per cent. of the nitrogen soluble in water and of 67 per cent. of the soluble organic nitrogen. In the case of the solid and liquid, fresh, there was a loss of 54 per cent. of total nitrogen, 67 per cent. of the water-soluble nitrogen, 97 per cent. of the ammonia and 60 per cent. of potash. Such enormous losses are worthy of careful consideration. They prove clearly enough that too much emphasis cannot be laid on the proper handling and care of manure. It should be also noted here that in one instance there was actually a gain in the soluble organic nitrogen, namely, in the case of the solid and liquid portion. In this case the exposure for sixty-two days, while it led to a loss of 54 per cent. of the total nitrogen, also led to an increase of 59 per cent. in the soluble organic nitrogen. This can only be explained by the assumption that part of the undigested residues were rendered soluble in the course of leaching by bacterial action.

The Experiment Plant.

For the sake of convenience, the diagram of the experiment plant is again reproduced here.

Diagram of Experiment.

Series.	A	B	C
1. Check	○	○	○
2. Minerals	○	○	○
3. Manure, solid, fresh	○	○	○
4. Manure, solid and liquid, fresh	○	○	○
5. Manure, solid, leached	○	○	○
6. Manure, solid and liquid, leached	○	○	○
7. Nitrate of soda, 5 gms	○	○	○
8. Nitrate of soda, 10 gms	○	○	○
9. Manure, solid, fresh; nitrate, 5 gms	○	○	○
10. Manure, solid, fresh; nitrate, 10 gms	○	○	○
11. Manure, solid and liquid, fresh; nitrate, 5 gms.	○	○	○
12. Manure, solid and liquid, fresh; nitrate, 10 gms.	○	○	○
13. Manure, solid, leached; nitrate, 5 gms.	○	○	○
14. Manure, solid, leached; nitrate, 10 gms.,	○	○	○
15. Manure, solid and liquid, leached; nitrate, 5 gms	○	○	○
16. Manure, solid and liquid, leached; nitrate, 10 gms	○	○	○
17. Sulfate of ammonia	○	○	○
18. Dried blood	○	○	○
19. Manure, solid, leached; sulfate of ammonia	○	○	○
20. Manure, solid, leached; dried blood	○	○	○

Application of Manures and Fertilizers.

The manures and fertilizers were applied August 1st, 1901. The manure was carefully weighed and uniformly distributed in the soil in the following manner: About one-half of the upper soil was first removed from the cylinder, the manure was placed in a tin pan, and a measured quantity of water was poured over it, and stirred until the whole mass was in a semi-liquid state. The contents of the pan were then distributed uniformly over the exposed area, the consistency of the mass permitting a very even distribution. Such a procedure was more satisfactory than the old method of mixing the manure with the soil, since in the latter case the manure was distributed in the soil in lumps, in spite of the care used to prevent this. After the addition of the manure, the soil that had been removed was again returned to the cylinder, the fertilizer was then distributed evenly over the surface, and the soil was again stirred.

Amounts Applied.

It was the aim to have the different kinds of manure applied uniform in amount, and slightly greater than would be used in ordinary practice, and corresponding with that frequently used in market gardening. The application was in no case so excessive as to render the conditions different from those obtained in good farm practice, or at the rate of sixteen tons per acre.

In the case of the concentrated nitrogenous substances the application of nitrate was somewhat different than in preceding years. Whereas formerly 5 and 10 gms., respectively, were applied on 7, 9, 11, 13 and 15, on the one hand, and on 8, 10, 12, 14 and 16, on the other, applications of 10 gms. only were made in 1902. The method of application was, however, somewhat different. On 7, 9, 11, 13 and 15 there was applied 5 gms. of nitrate at the time of seeding, early in August, 1901; on 8, 10, 12, 14 and 16 only 2.5 gms. were applied at the same date. On April 21st 5 gms. of nitrate were again applied on all of the nitrate plots, namely, on 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16; and on May 12th the remaining 2.5 gms. were applied on 8, 10, 12, 14 and 16. There were thus applied 10 gms. of sodium nitrate on each of the nitrate cylinders, but while this amount was applied in two portions on 7, 9, 11, 13 and 15, it

was applied in three portions on 8, 10, 12, 14 and 16. On the ammonia plots, 17 and 19, 2 gms. were applied in the fall, and the remaining 6 gms. in April. All of the dried blood was applied, at the time of seeding, in the corresponding cylinders.

The usual amounts of acid phosphates and of muriate, and namely, 20 gms. and 10 gms., respectively, were added at the time of seeding. The quantities of manure applied were: Of solid, fresh, 2 lbs. 5 oz.=4.09 gms. N.; of solid and liquid, fresh, 1 lb. 13 oz.=4.06 gms. N.; of solid, leached, 2 lbs. 2 oz.=4.01 gms. N.; of solid and liquid, leached, 2 lbs. 9 oz.=3.96 gms. N.

During the growing season of 1902 there was but slight rainfall in May and June, and water was added from the hose on May 12th, May 24th, June 4th and June 9th. The same amount was added in each case, so as not to affect the different soils to an unequal extent.

The Crops Grown.

The crop grown in 1901–02 was timothy. One-half of a gram of timothy seed was sown in each soil August 10th, 1901. The germination was satisfactory in most cases, but was poor in series 1 and 2, where no nitrogenous materials were applied. As with the preceding crop, wheat, the timothy germinated in the late summer, and was harvested in the following year. The seasonal conditions here were different than in the case of crops planted in the early spring and harvested in the fall of the same year. It was to be expected that somewhat different chemical, physical and biological conditions would prevail, since the season of growth was longer and included the winter months. Because of those seasonal differences the results are not concordant with those of other seasons. In calculating the yield the average of the three plots in any one series is usually taken, and, by subtracting the average yield on the check plots, the yield due to the particular manure or fertilizer is obtained. Thus, by subtracting the average yield on series 2 from that on series 8, the yield due to the 10 gms. of nitrate applied on the latter series is obtained. It is necessary, of course, to assume here that the amount of nitrogen obtained from the soil itself by the crops on series 8 is equal to the amount of nitrogen obtained from the soil by the crops on series 2, where no nitrogen is applied. As a matter of fact, the average amount of nitrogen withdrawn from the

soil itself on series 8 is never equal to, but always greater than, the average amount of nitrogen withdrawn from the soil on series 2. The reason for this is evident, if we consider that the soil nitrogen becomes soluble very gradually, and the thoroughness with which this soluble nitrogen is utilized by the growing crop depends on the root development of the individual plants. It is quite apparent that the plants on series 2 will grow but slowly, since the amount of nitrogen placed at their disposal is very meagre. In consequence of this limited growth the root development of the plants will be very limited, and therefore not capable of appropriating all, or most, of the nitrogen rendered soluble in the course of the season. On the other hand, the nitrate nitrogen offered to the plants on series 8 will make possible a good root development and a more thorough utilization of the nitrogen derived from the soil itself. Moreover, the sodium nitrate will exert a solvent action on the soil humus over and above that exerted by the substances applied on series 2. Thus it will be seen that the average amount of nitrogen credited to the nitrate on series 8 will partly consist of the nitrogen derived from the soil in excess of the average amount derived from the soil of series 2. Since the soil nitrogen becomes soluble but slowly, the amount obtained by the growing crop will be directly proportional to the length of the growing season. Hence it follows that, everything else being equal, the amount of nitrogen credited to the nitrate will be greater for the long season than it would be for the short season. Unfortunately for the experiment of 1901–02, everything else was not equal during this season. The seasonal conditions were very unfavorable for the growth of timothy in the field, and they were undoubtedly as unfavorable in the experiment plots. Under such conditions the production of plant-substance is not governed, in the main, by the amount of plant-food present in the soil. In other words, it is not sufficient to have conditions favorable for the absorption of plant-food, but there must be also conditions favorable for the assimilation of the plant-food. When the climatic conditions permit only a limited assimilation of the plant-food taken from the soil, the presence of large amounts of nitrogen, of phosphoric acid or of potash in the soil would be of little avail to the crop. If the amount of nitrogen, for instance, that may be assimilated during the season should equal 1 gm., the yield from plots containing 1, 2 and 3 gms., respectively, would be the same, for no more than 1 gm. would be utilized in any case.

There was one other condition which affected the utilization of the different nitrogenous materials applied. The seed was sown early in August, and there was considerable growth made before the cold weather came. The growth was greater where larger quantities of soluble nitrogen were present, and considerable amounts of this soluble nitrogen were converted into organic matter. During the winter the young grass above ground died, and the nitrogen contained in this dead plant-substance could not be utilized for further growth when spring came. Hence the large amounts of soluble nitrogen withdrawn from the soil in the early fall diminished, to that extent, the resources of the crops in the spring. Naturally enough the underground portion—that is, the root growth—was not killed in the winter, and was in a condition to exploit the soil nitrogen more thoroughly than the root growth in the series where no soluble nitrogen had been applied. These considerations may account, in some measure, for the comparatively low recovery from the plots where nitrogen was applied in one form or another.

Results of the Timothy Experiment, 1901-1902.

The accompanying table shows the actual dry matter, both in the first cuttings and in the aftermath from each series, the percentage of nitrogen found, the gain in nitrogen due to the materials added and the percentage of the applied nitrogen recovered. In all cases the net gains in the different series are derived by subtracting the average gain obtained on series 2, on which minerals only were applied, from the average gain on that particular series.

In studying the results as indicated by the analytical data, the seasonal conditions, as already pointed out, should be considered.

Timothy, 1902.

	First cut.							Aftermath.							Both crops.			
	Nitrogen applied.	Dry matter in crop.	Nitrogen in dry matter.	Nitrogen in crop.	Increase over check plot.	Per cent. of nitrogen recovered.	Average.	Residual nitrogen.	Dry matter in crop.	Nitrogen in dry matter.	Nitrogen in crop.	Increase over check plot.	Per cent. of nitrogen recovered.	Average.	Nitrogen in crop.	Increase over check plot.	Per cent. of nitrogen recovered.	Average.
	gms.	gms.	%	gms.	gms.	%	%		gms.	%	gms.	gms.	%	%	gms.	gms.	%	%
1 A		49.2	1.272	0.626					30.8	1.589	0.489				1.115			
B		44.1	1.183	0.522					28.1	1.502	0.422				0.944			
C		44.9	1.080	0.485					34.8	1.567	0.545				1.030			
2 A		69.2	0.838	0.580					20.5	1.872	0.384				0.964			
B		59.0	0.881	0.520	(0.546)				16.7	1.903	0.318	(0.351)			0.838	(0.963)		
C		57.7	0.931	0.537					35.4	1.556	*0.551				1.088			
3 A	4.03	152.8	0.697	1.065	0.519	12.9		3.51	33.7	1.549	0.522	0.171	4.9		1.587	0.624	15.5	
B		135.1	0.749	1.012	0.466	11.6	12.7	3.56	38.2	1.790	0.684	0.333	9.4		1.696	0.733	18.2	18.4
C		126.5	0.778	1.094	0.548	13.6		3.48	51.0	1.447	0.738	0.387	11.1		1.832	0.869	21.6	
4 A	4.06	162.4	0.693	1.125	0.579	14.3		3.48	28.3	1.521	0.430	0.079	2.3		1.555	0.592	14.6	
B		120.6	0.697	0.841	0.295	*7.3	13.4	3.76	27.2	1.702	0.468	0.112	3.0		1.304	0.341	*8.4	13.8
C		136.1	0.774	1.053	0.507	12.5		3.55	44.5	1.481	0.659	0.308	8.7		1.712	0.749	18.4	
5 A	4.01	145.3	0.680	0.988	0.442	11.0		3.57	33.6	1.547	0.520	0.169	4.7		1.508	0.545	13.6	
B		135.7	0.717	0.973	0.427	10.6	11.4	3.58	30.9	1.709	0.528	0.177	4.9		1.501	0.538	13.4	16.4
C		126.4	0.834	1.054	0.508	12.7		3.50	52.3	1.539	0.805	0.454	13.0		1.859	0.896	*22.3	
6 A	3.96	154.8	0.712	1.102	0.556	14.0		3.40	36.8	1.570	0.578	0.227	6.7		1.680	0.717	18.1	
B		149.3	0.744	1.111	0.565	14.3	13.4	3.39	42.3	1.597	0.676	0.325	9.6		1.787	0.824	20.8	20.3
C		126.6	0.800	1.013	0.467	11.8		3.49	56.7	1.460	0.828	0.477	13.7		1.841	0.868	21.9	
7 A	1.55	107.1	0.769	0.824	0.278	17.8		1.27	18.5	1.667	0.308				1.132	0.169	10.9	
B		120.0	0.716	0.859	0.313	20.0	19.9	1.24	17.6	1.751	0.308				1.167	0.204	13.2	16.7
C		104.2	0.846	0.882	0.336	21.5		1.21	32.6	1.486	0.484	0.133	11.0		1.366	0.403	51.7	
8 A	1.55	122.1	0.724	0.884	0.338	21.8		1.21	24.0	1.581	0.379	0.028	2.3		1.263	0.300	19.4	
B		130.6	0.780	1.019	0.473	30.5	29.7	1.08	20.3	1.557	0.316				1.335	0.377	24.0	29.2
C		131.7	0.848	1.117	0.571	36.8		0.98	35.5	1.500	0.533	0.182	18.6		1.650	0.687	*44.3	
9 A	5.58	211.0	0.767	1.618	1.072	19.2		4.51	46.3	1.456	0.674	0.323	7.1		2.292	1.329	23.8	
B		166.7	0.854	1.424	0.878	15.7	17.4	4.70	40.2	1.499	0.603	0.252	5.3		2.027	1.064	19.0	22.6
C		170.6	0.885	1.510	0.964	17.3		4.62	58.5	1.447	0.846	0.495	10.7		2.356	1.393	24.9	
10 A	5.58	174.4	0.890	1.552	1.006	18.0		4.57	51.4	1.427	0.723	0.382	8.4		2.285	1.322	23.7	
B		182.6	0.884	1.614	1.068	19.1	17.9	4.51	40.8	1.577	0.643	0.292	6.5		2.257	1.394	25.0	25.3
C		152.3	0.967	1.473	0.927	16.6		4.65	69.5	1.431	1.015	0.664	14.3		2.488	1.525	27.3	

Timothy, 1902—Continued.

	FIRST CUT.							AFTERMATH.							BOTH CROPS.			
	Nitrogen applied.	Dry matter in crop.	Nitrogen in dry matter.	Nitrogen in crop	Increase over check plot.	Per cent. of nitrogen recovered.	Average.	Residual nitrogen.	Dry matter in crop.	Nitrogen in dry matter.	Nitrogen in crop.	Increase over check plot.	Per cent of nitrogen recovered.	Average.	Nitrogen in crop.	Increase over check plot.	Per cent. of nitrogen recovered.	Average.
	gms.	gms.	%	gms.	gms.	%	%		gms.	%	gms.	gms.	%	%	gms.	gms.	%	%
11 A	5.61	174.0	0.906	1.576	1.030	18.4	....	4.58	46.2	1.426	0.659	0.308	6.7	....	2.235	1.272	22.7	....
11 B	....	190.8	0.868	1.656	1.110	19.8	18.6	4.50	29.1	1.654	0.481	0.130	2.7	....	2.137	1.174	20.9	21.6
11 C	....	177.7	0.860	1.528	0.982	17.5	....	4.63	42.6	1.477	0.629	0.278	6.5	....	2.157	1.194	21.3	....
12 A	5.61	221.1	0.820	1.813	1.267	22.6	....	4.34	34.4	1.485	0.511	0.160	3.7	....	2.324	1.361	24.3	....
12 B	....	177.4	0.870	1.548	0.997	17.8	20.3	4.61	27.1	1.520	0.412	0.061	1.3	....	1.955	0.992	17.7	21.7
12 C	....	180.9	0.939	1.699	1.153	20.6	....	4.46	38.5	1.469	0.566	0.215	4.8	....	2.265	1.302	23.2	....
13 A	5.56	192.9	0.751	1.449	0.903	16.2	....	4.66	45.2	1.420	0.642	0.291	6.2	....	2.091	1.128	20.3	....
13 B	....	177.8	0.763	1.407	0.861	15.5	17.1	4.70	43.9	1.481	0.650	0.299	6.4	....	2.057	1.094	19.7	21.5
13 C	....	179.1	0.910	1.630	1.084	19.5	....	4.48	44.9	1.557	0.699	0.348	7.8	....	2.329	1.366	24.6	....
14 A	5.56	210.0	0.753	1.581	1.035	18.6	....	4.52	46.4	1.583	0.735	0.384	8.5	....	2.316	1.353	24.3	....
14 B	....	216.3	0.848	1.834	1.288	23.2	19.8	4.27	50.2	1.302	0.654	0.303	7.1	....	2.488	1.525	27.4	24.8
14 C	....	161.3	0.897	1.447	0.901	16.2	....	4.66	51.9	1.510	0.784	0.433	9.3	....	2.231	1.268	22.8	....
15 A	5.51	180.1	0.770	1.387	0.841	15.3	....	4.67	40.7	1.480	0.577	0.226	4.9	....	1.964	1.001	18.1	....
15 B	....	163.1	0.738	1.204	0.658	11.9	14.5	4.85	36.2	1.505	0.545	0.194	4.0	....	1.749	0.786	14.3	17.7
15 C	....	167.4	0.860	1.440	0.894	16.2	....	4.62	41.1	1.624	0.667	0.316	6.8	....	2.107	1.144	20.8	....
16 A	5.51	206.5	0.852	1.759	1.213	22.0	....	4.30	58.8	1.447	0.851	0.500	11.6	....	2.610	1.647	29.9	....
16 B	....	188.1	0.860	1.618	1.072	19.5	20.6	4.44	53.5	1.338	0.716	0.365	8.2	....	2.334	1.371	24.9	26.1
16 C	....	173.9	0.954	1.659	1.113	20.2	....	4.40	37.6	1.615	0.607	0.256	5.8	....	2.266	1.303	23.6	....
17 A	1.62	89.9	0.795	0.716	0.170	10.5	....	1.45	23.2	1.570	0.364	0.013	0.9	....	1.080	0.117	*7.2	....
17 B	....	122.7	0.738	0.906	0.360	22.0	....	1.26	21.2	1.484	0.315	....	....	....	1.221	0.258	15.9	15.9
17 C	....	107.8	0.738	0.796	0.250	15.4	....	1.37	19.5	1.498	0.292	....	....	....	1.088	0.125	*7.7	....
18 A	1.55	100.4	0.783	0.786	0.240	15.5	....	1.31	28.9	1.493	0.431	0.080	6.1	....	1.217	0.254	16.4	....
18 B	....	85.5	0.740	0.633	0.087	5.6	....	1.46	30.1	1.418	0.427	0.076	5.2	....	1.060	0.097	*6.3	16.4
18 C	....	90.8	0.771	0.700	0.154	10.0	....	1.40	20.7	1.634	0.338	....	....	....	1.038	0.075	*4.8	....
19 A	5.63	176.4	0.774	1.365	0.819	14.5	....	4.81	47.2	1.352	0.638	0.287	6.0	....	2.003	1.040	18.5	....
19 B	....	156.2	0.890	1.390	0.844	15.0	14.7	4.79	39.5	1.465	0.579	0.228	4.8	....	1.969	1.006	17.9	17.8
19 C	....	160.9	0.851	1.369	0.823	14.6	....	4.81	34.9	1.576	0.550	0.199	4.1	....	1.919	0.956	17.0	....
20 A	5.56	167.2	0.827	1.383	0.837	15.1	....	4.72	54.0	1.335	0.721	0.370	7.8	....	2.104	1.141	20.5	....
20 B	....	160.0	0.727	1.163	0.617	11.1	13.9	4.94	52.7	1.271	0.670	0.319	6.5	....	1.833	0.870	15.6	19.7
20 C	....	164.0	0.858	1.407	0.861	15.5	....	4.70	55.9	1.481	0.828	0.477	10.1	....	2.235	1.272	22.9	....

Average Amount of Dry Matter in Crop, 1901-1902.

Series.	First Cutting. gms.	Aftermath. gms.	Total Crop. gms.
1	46.1	31.3	77.4
2	61.9	24.2	86.1
3	138.1	40.9	179.0
4	139.7	33.3	173.0
5	135.8	38.9	174.7
6	143.6	45.3	188.9
7	110.4	22.9	133.3
8	128.1	26.6	154.7
9	182.8	48.3	231.1
10	169.8	53.9	223.7
11	180.8	39.3	220.1
12	193.1	33.3	226.4
13	183.3	44.7	228.0
14	195.9	49.5	245.4
15	170.2	39.3	209.5
16	189.5	49.9	239.4
17	106.8	21.3	128.1
18	92.2	26.6	118.8
19	164.5	40.5	205.0
20	163.7	54.2	217.9

The above columns show that there was more dry matter on series 2 than there was on series 1 in the first cutting, but more dry matter on series 1 in the aftermath. When the first cutting and aftermath are taken together, there was more dry matter produced on series 2. There were comparatively slight differences in the yield of dry matter on 3, 4, 5 and 6. Comparing 7 and 8, we find that the three fractional applications of the 10 gms. of nitrate on 8 led to a greater production of dry matter than the two fractional applications of the same amount on 7. On 9 there was a slightly greater yield than on 10, but the conditions are reversed on 11 and 12. Similarly, there was a greater yield of dry matter on 14 than there was on 13, and a greater yield on 16 than there was on 15, showing that the three fractional applications were more favorable to the production of plant-substance. The dried blood was inferior as a source of nitrogen, when used alone, than the ammonia, but together with the manure it was superior to the ammonia and the manure, when the total crop is considered. The leached manure gave better returns when used together with nitrate than it did when used together with either ammonium sulphate or dried blood.

Comparing the yields of dry matter in the aftermath alone, we find

that, in some instances, the yield was not greater than on series 1. Thus the yields of dry matter on series 2, 7, 8, 17 and 18 are even smaller than that on 1. It will also be observed that there was a greater yield of dry matter in the aftermath on 3 than there was on 4, and the same relations hold good on 9 and 10 as compared with 11 and 12, showing that the solid and liquid, fresh, left the soil poorer in soluble nitrogen after the first cutting than did the solid, fresh, alone. There was also a greater yield of dry matter in the aftermath of 18 than there was in the aftermath of 17, notwithstanding the fact that in the first cutting more dry matter was produced on 17. Similarly, there was more dry matter in the aftermath of 10 than there was in the aftermath of 19, the yield in the former case being greater than that of any other series.

Average Per Cent. of Nitrogen in Dry Matter.

Series.	First Cutting. gms.	Aftermath. gms.	Total Crop. gms.
1	1.180	1.550	1.328
2	0.882	1.727	1.119
3	0.765	1.584	0.952
4	0.744	1.552	0.899
5	0.740	1.589	0.929
6	0.749	1.532	0.936
7	0.774	1.602	0.916
8	0.786	1.601	0.926
9	0.829	1.466	0.963
10	0.910	1.479	1.047
11	0.877	1.499	0.989
12	0.874	1.489	0.920
13	0.761	1.485	0.903
14	0.827	1.463	0.956
15	0.789	1.516	0.926
16	0.886	1.453	1.042
17	0.755	1.516	0.881
18	0.766	1.500	0.930
19	0.837	1.454	0.958
20	0.805	1.363	0.990

Comparing the percentages of nitrogen as given in the above table, we find that the relations in the first cutting and in the aftermath are reversed in most cases. Thus in the first cutting the average per cent. of nitrogen in the crop from series 1 is greater than that in the crop from series 2. In the aftermath, on the other hand, the dry matter from series 2 is richer in nitrogen than the dry matter from

series 1. Similarly, in the first cutting from series 3 there is a higher content of nitrogen than there is in the first cutting from series 4. The same is true in the aftermath of 5 and 6, of 7 and 8, of 13 and 14, of 15 and 16, of 17 and 19, and 18 and 20. Taking the average of the yields on 9, 10, 11 and 12, where the solid and solid and liquid, fresh, were applied, we find here a somewhat higher content of nitrogen than in the average yield from 13, 14, 15 and 16, where the leached manures were applied. There is a very slight difference in favor of the leached manures, a relation which also holds good in the total yields from 3 and 4, on the one hand, and from 5 and 6 on the other. Comparing 8 with 17 and 18, we find a somewhat higher content of nitrogen in the dry matter from the nitrate plot.

Average Amount of Nitrogen in Crop, 1901-1902.

Series.	First Cutting. gms.	Aftermath. gms.	Total Crop. gms.
1	0.544	0.485	1.029
2	0.546	0.418	0.964
3	1.057	0.648	1.705
4	1.039	0.517	1.556
5	1.005	0.618	1.623
6	1.075	0.694	1.769
7	0.855	0.367	1.222
8	1.007	0.409	1.416
9	1.517	0.708	2.225
10	1.546	0.797	2.343
11	1.587	0.589	2.176
12	1.688	0.496	2.184
13	1.395	0.664	2.059
14	1.621	0.724	2.345
15	1.344	0.596	1.940
16	1.679	0.725	2.404
17	0.806	0.323	1.129
18	0.706	0.399	1.105
19	1.375	0.589	1.964
20	1.318	0.739	2.157

The comparison of the yield of nitrogen in the crops from the several series brings out some interesting relations. It appears that in the first cutting there was practically as much nitrogen in the crop from series 1 as there was in that from series 2. In the aftermath there was more nitrogen in the crop from series 1, as there was in the total crop. Referring back to another table, we find that the

average total yield of dry matter was 77.4 gms. on series 1 and 86.1 gms. on series 2. The 77.4 gms. of dry matter on series 1 contained 1.029 gms. of nitrogen, while the 86.1 gms. of dry matter on series 2 contained only 0.964 gms. of nitrogen. The differences are even more striking in the first cutting. We find here that the 46.1 gms. of dry matter on series 1 contained practically the same amount of nitrogen as the 61.9 gms. of dry matter on series 2. The conditions of growth are evidently different here. On series 2, where an abundance of phosphoric acid and of potash is present, the nitrogen is the controlling factor of growth as far as plant-food is concerned, and it is used here with greater economy than in series 1, where, apparently, still another plant-food constituent is present in slight proportion. From the appearance of the plants during the season it might be concluded that there is a lack of phosphoric acid in the soils of series 1. The plants on this series were very small and dark-green in color, a circumstance that would indicate lack of phosphoric acid. This supposition is strengthened by the observation of Wilfarth and Wimmer.[1] They state that the "lack of nitrogen, phosphoric acid or potash becomes apparent in the reduction of yield. When nitrogen, phosphoric acid and potash are absent entirely, the production of plant-substance is almost equal to nothing, and increase of growth takes place only as long as the plant-food present in the seed holds out. When the lacking plant-food constituent is added, and an excess of all other plant-food present, the amount of plant-substance produced is almost proportional to the quantity of that plant-food constituent added, and the increase is continued until the maximum limit is reached. But if we should assume that a small quantity of plant-food is present in the soil, so that the plants may reach a certain development, and yet experience a lack of food, there would appear striking differences in the plants when nitrogen, phosphoric acid or potash should be lacking in the different cases.

"Apart from the decreased yield, the lack of nitrogen and phosphoric acid may be easily distinguished. Where there is lack of nitrogen the plants lose their normal green color, and become bright green or yellow. The leaves finally dry up to a light, brownish, yellow color.

"On the other hand, where there is a lack of phosphoric acid, the leaves assume a dark-green, at times an almost blue-green, color, depending on the greater or slighter excess of nitrogen present.

[1] Journal für Landw. 51 (1903), p. 129.

When the lack of phosphoric acid is very pronounced, there appear on the edges of the leaf, and later over the entire leaf, black spots, and the leaf finally dries up to a dark-brown or a blackish-green color.

"When the plant grows in the presence of slight or moderate amount of potash, not sufficient for a maximum yield, it does not differ at first from normally-nourished plants, and this condition may continue for weeks or months, depending on the kind of plant and the amount of potash present. While the lack of nitrogen or of phosphoric acid is at once apparent by decreased growth, even before the appearance of color changes in the leaves, the lack of potash becomes evident in the following manner:

"Yellowish spots appear on the leaves; these spots soon turn brown, and in some plants white. The spots soon spread over the entire leaf surface, but the midrib, the stem and leaf nerves, and points immediately adjoining, assume a dark-green color. As soon as the spots appear, at times even sooner, the leaves assume, for the most part, a peculiarly twisted form, with the convex surface on top."

These observations lead to the belief that there is a lack of phosphoric acid in the soils of series 1.

Comparing the fresh manures, we find that there was a greater yield of nitrogen in the total crop from series 3 than there was in the crop from series 4. The same relation holds good in 9 and 11, and in 10 and 12, where these manures were used in combination with nitrate. This circumstance is in favor of the view that a considerable proportion of the soluble nitrogen was consumed in the fall, and that it was rendered unavailable in the plant portions killed during the following winter. This view is further strengthened by the results in 7 and 8, and in 9 and 10, and in 11 and 12. While equal quantities of nitrate were applied in 7 and 8, the application in the fall was 5 gms. in 7 and 2.5 gms. in 8. This treatment led to more extensive growth in the fall on 7, and resulted in a more extensive withdrawal of soluble nitrogen from the series. Similarly, we find that in 10, where 8 and 3 were combined, there was a greater amount of nitrogen in the crop than there was in 9, where 7 and 3 were combined. This is also true of 11 and 12, respectively, although in the latter instance the differences were not as marked. In case of the leached manures there was a greater yield of nitrogen in 6 than there was in 5. The same relation holds good in 14 and 16, where the solid and the solid and liquid, leached, respectively, were

used in combination with 10 gms. of nitrate. In 13 and 15, however, this relation does not hold good. Neither is the yield in 19 greater than that in 20, although in the first cutting there was more nitrogen obtained from 19 than there was from 20. The difference is due to the high yield of nitrogen in the aftermath of 20. On the whole, there was a slightly higher return from the fresh manures than there was from the leached manures, but the difference is very slight, since the total yield from 3, 4, 9, 10, 11 and 12 was 11.189 gms., while from 5, 6, 13, 14, 15 and 16 it was 11.150 gms.

THE AVAILABILITY OF THE NITROGEN IN THE SOLID, AND IN THE SOLID AND LIQUID MANURE, FRESH.

In calculating the relative availability of the different nitrogenous materials used, the yield of nitrogen in the crop from series 8 was taken as the standard of comparison, as in former years. The amount of nitrogen recovered from series 8 is taken at 100, and the amounts recovered from the other soils are measured according to this scale. Because of unfavorable seasonal conditions, as was pointed out above, the results for the growing season 1901–02 are not as satisfactory as could have been expected. The soluble nitrogen that was withdrawn in the fall of 1901 did not reappear in the new growth of the following spring, except in so far as it entered into the development of the root portions that lived through the winter. This circumstance affected the growth on the soils where the more soluble forms of nitrogen had been applied, to a much greater extent than it did the growth on the other soils.

Bearing this in mind, it becomes easier to understand why, in the first cutting, the recovery from series 3, where the solid, fresh, was used, is but slightly less than the recovery from 4, where the solid and liquid portion, fresh, was used; and, in fact, the recovery from 4 is actually less than that from 3, if we are to take the average of all three plots of series 4. With the exception of the season 1900–01, where the conditions were highly favorable for the utilization of the solid manure, the solid and liquid portion, fresh, always showed a marked superiority to the solid, fresh. In some instances the recovery from the solid and liquid portion was almost three times as great as the recovery from the solid portion alone. This can be readily ascertained by consulting the reports for 1899, 1900 and 1901. Meanwhile, the following tabulation will show the relations in this respect:

Nitrogen Recovered.

	Solid, Fresh. %	Solid and Liquid, Fresh. %
1898	7.44	22.04
1899	8.30	40.20
1900	19.78	38.61
1901	30.20	29.90
1902	*18.40	13.8

The above figures show that, in 1901, the solid, fresh, made a better showing than the solid and liquid, fresh, contrary to previous experience, and due undoubtedly to different seasonal conditions. The results of 1902, while similar to those of the season immediately preceding, as regards the availability of the solid, and of the solid and liquid portions, fresh, are yet different in that the recovery in either case was comparatively slight for the very long season of growth. The possible causes of this circumstance have already been discussed.

THE AVAILABILITY OF THE NITROGEN IN THE SOLID, AND IN THE SOLID AND LIQUID, LEACHED.

The leached manures, containing, as they did, less soluble nitrogen than the corresponding fresh manures, were not affected to such an extent as the latter by the seasonal conditions. They had a more lasting effect than the fresh manures, for they gave, on the whole, a better yield in the aftermath. The solid and liquid, leached, showed a greater recovery than the solid, leached, alone, and a greater recovery than either of the fresh manures. The recovery from the leached manures for the several seasons are given in the following tabulation:

Nitrogen Recovered.

	Solid, Leached. %	Solid and Liquid, Leached. %
1898	8.40	13.80
1899	7.38	22.06
1900	16.50	26.94
1901	23.70	19.40
1902	†16.4	20.30
Average	14.48	20.50

* Total crop.

† Average of two.

It will be seen from the above that the recovery for 1902 from either the solid, leached, or from the solid and liquid, leached, is very near the average for the five seasons.

THE RELATIVE AVAILABILITY OF THE NITROGEN IN THE FORM OF NITRATE, AMMONIA AND OF ORGANIC MATTER IN DRIED BLOOD,

The recovery for the nitrate was less for the season 1901–02, and the same is true of the ammonium sulphate and of the dried blood. The seasonal conditions are undoubtedly responsible for these results. The extent of the variations in the recovery, from season to season, for the nitrate, ammonium sulphate and the dried blood may be seen in the following table.

Nitrogen Recovered.

	Nitrate.	Ammonium Sulphate.	Dried Blood.
	%	%	%
1898	44.38	44.24	42.36
1899	69.00	50.30	40.40
1900	76.30	68.84	52.15
1901	97.20	88.50	73.60
1902	29.2	*15.90	*16.40
Average	61.71	53.56	44.98

It will be noticed that the recovery for 1901–02 (the latter season included) is far below the average recovery for all seasons. Furthermore, the recovery in 1901–02 from the dried blood is greater than that from the ammonium sulphate. When, however, the average for the three is taken in each case, the recovery from 17 becomes greater than that from 18, and namely, 10.3 and 9.2, respectively. Comparing the relative yields in the aftermath, we find that in four out of the nine plots the yield of nitrogen was actually greater on the check plots. Of the remaining five plots, two show a very slight increase over the average in the check plots, and three show a rather small increase. It appears, therefore, that the nitrate, ammonium sulphate and the dried blood showed practically no residual effect in the aftermath.

* Average of two.

THE EFFECT OF THE USE OF THE SOLID, AND OF THE SOLID AND LIQUID MANURE, FRESH AND LEACHED, WITH NITROGEN IN THE FORM OF NITRATE, AMMONIA AND OF ORGANIC MATTER.

The object of these combinations was to study the availability of the different nitrogenous substances, when used together, as well as singly. It was, moreover, intended to determine whether the manure would lead to denitrification when applied together with nitrate. As in previous years, the clear manure, free from any admixture of litter, was used, and the amount of manure applied was in no case greater than that applied in actual practice. This season's experience tends to confirm the earlier results in many respects. As in the other cases, the nitrogen in the different combinations showed, in a number of instances, greater efficiency than where these forms were used singly. The reason for this we must seek in the fact that no single form is so well adapted to nourish the plant continually and uniformly as are the proper combinations. Such uniform feeding not only enables a uniform and healthy growth, but it also makes a more thorough utilization of the plant-food made available by providing a better root system. Moreover, the nitrogen salts applied would, of themselves, help to make soluble the organic matter, while the organic portion would improve the physical condition of the soil. These considerations would explain why, in many instances, the calculated recovery is less than the actual recovery. Notwithstanding the peculiar season conditions of 1901–02, the calculated recovery is, in all but one case, less than the actual recovery. Such results show clearly enough that there was no denitrification in the soil in any of the cylinders. At the same time, there was undoubtedly a loss of nitrogen from the different soils, as indicated by the soil analyses. It is difficult to determine in what manner the losses largely occurred, although they should undoubtedly be attributed to more than one single cause.

The difference between the per cent. of nitrogen actually recovered and the per cent. recoverable, calculated, represents the losses due to all causes; the difference is expressed in percentage in the last column of the accompanying table. The per cent. recovered is, in almost every case, greater on the even series, 8, 10, 12, 14 and 16, than it is on the odd nitrate and manure series, 7, 9, 11, 13 and 15. The recovery from the solid manure, fresh, when used in combina-

tion with nitrate, is larger than that from the solid and liquid, fresh, when used in combination with nitrate. Thus, the average recovery for the series 1 and 10 is 23.9 per cent., while the recovery for series 11 and 12 is 21.6 per cent. The recovery from the solid manure, leached, in combination with nitrate, is greater than the recovery from the solid and liquid, leached, in combination. Taking the average recovery from 9, 10, 11 and 12, where the solid and the solid and liquid, fresh, were used, we find it slightly higher than the corresponding average recovery from 13, 14, 15 and 16. The recovery from 17 and 18, where ammonium sulphate and dried blood, respectively, were used as the source of nitrogen, is comparatively slight. Where these materials were used in combination, the recovery is considerably higher. Where the manures were used singly, the recovery from the solid, fresh, is greater than that from the solid, leached. On the average, the recovery from the fresh manure is somewhat smaller than that from the leached manures where the materials were used singly.

Timothy, 1901-1902.

Series.	Nitrogen Recovered.	Calculated Recovery.	Nitrogen not Recovered.
	%	%	%
3	18.4	....	....
4	13.8	....	....
5	16.4	....	....
6	20.3	....	....
7	16.7 or 12.0*	....	....
8	29.2 or 21.7*	....	....
9	22.6	19.7	....
10	25.3	23.2	....
11	21.6	15.2	....
12	21.7	18.6	....
13	21.5	16.5	....
14	24.8	20.0	....
15	17.7	19.3	8.2
16	26.1	22.8	....
17	10.3 or 15.9*	....	....
18	9.2 or 16.4*	....	....
19	17.8	14.7	....
20	19.7	14.4	....

In all but one case the actual recovery exceeds the calculated recovery. This would show that whatever the low recoveries may be due to, they are not due to denitrification. For the sake of com-

* Average of two.

parison, the relative availability of the different substances, as found for the several seasons, are again tabulated here, together with the results for 1901–02:

	Corn. 1898.	Oats. 1899.	Oats and Millet. 1899.	Oats. 1900.	Oats and Corn. 1900.	Wheat. 1901.	Timothy. 1902.
	%	%	%	%	%	%	%
Nitrate of soda........	100	100	100	100	100	100	100
Sulphate of ammonia..	99.5	72.9	77.9	99.2	87.7	91.0	38.3 or 54.4
Dried blood...........	95.4	58.5	61.3	68.3	73.1	75.7	34.6 or 56.9
Solid manure, fresh....	16.8	12.0	43.1	14.2	26.4	31.1	63.0
Solid manure, leached..	37.9	12.1	46.4	9.7	22.0	24.4	56.1
Solid and liquid, fresh..	49.7	58.2	88.4	40.1	51.5	30.8	47.2
Solid and liquid, leached	50.4	20.0	33.0	28.9	35.9	19.9	69.5

The apparently high availability of the manures, and particularly of the solid, fresh, and the solid and liquid, leached, is due to the comparatively small recovery from the nitrate plots. Since the yield on series 8 is taken as the standard of comparison, its diminution would result in a corresponding increase in the relative availability of the other nitrogenous materials used. The availability of the ammonia nitrogen and of the dried blood nitrogen was below the average in 1901–02, even in relation to the nitrate.

The Nitrogen Content of the Cylinder Soils.

The analytical study of the nitrogen content of the crops from the cylinder plots gains in interest as it is supplemented by the study of the nitrogen content of the corresponding soils. The nitrogen derived from the soil itself undoubtedly plays an important part in the growth of the crop. Thus, in the timothy experiment, 1901–02, the crop on the check series obtained from the soils 0.963 gms. of nitrogen during the season's growth—a quantity which is equivalent to more than 50 per cent. of the total yield on many of the soils where nitrogen had been applied. This very considerable quantity of nitrogen markedly affects the interpretation of the results in the study of the relative availability of the different nitrogenous materials. It becomes necessary, for this reason, to give some consideration, at least, to the solvent action which any particular manurial application may exert on the inert soil nitrogen. Starting with a given quantity of sodium nitrate, on the one hand, and of manure on the other, the crop returns will

not necessarily express the exact relation which the soluble nitrogen in the one bears to that of the other. The manure creates in the soil conditions which are not created by the nitrate, and these conditions become intensified on each side with the succeeding seasons, until the two originally identical soils become very dissimilar. It will be seen from the analyses given below that, in the course of five seasons, the soils in the different series have become modified to a great extent. This divergence in the composition of the soil itself makes more difficult the interpretation of the analyses of the crops. At the same time, it is also the purpose of these experiments to reckon with the changing conditions and to follow them to their logical conclusion. The new soil conditions thus created have their counterpart in practical agriculture, and it is evident that, where the conditions are similar, similar results may also be expected. Hence there is reason to believe that the experience and information gained in connection with the cylinder experiments may find an acceptable application in actual practice.

The cylinders of the loam series contained originally 160 pounds of soil in each case. This soil was derived from a shale area that, in so far as it is known, had never been under cultivation. Notwithstanding this, the shale material was rich in nitrogen, containing somewhat less than .2 per cent. of total nitrogen. The preparation of this soil and the arrangement in the cylinders was discussed in detail in the Annual Report for 1899. It may be added here that the shale formed a compact, fine soil, which did not permit such rapid oxidation as took place in the lighter soils, which contained 50 per cent., by weight, of quartz sand.

The Analytical Operations.

Samples for analysis were obtained from the respective cylinders by means of the sampling tube, described in the report of the soil chemist for 1901. Four cores were taken from each cylinder, and, after the soil was thoroughly mixed, 225–250 gms. were placed in an air-tight glass jar and carried to the laboratory. They were then air-dried, ground in a porcelain mortar, until all of the sample passed through a .5 mm. sieve, and thoroughly mixed. It was found here that, because of the large amount of clay in the soil, the 20-gm. samples taken for the determination of nitrogen did not give satis-

factory results, unless very considerable quantities of sulphuric acid were used for digestion. However, large quantities of sulphuric acid are objectionable, because of the greater quantities of caustic soda required for its neutralization, and also because of the greater difficulty in transferring. For these reasons, only 10 gms. of the soil were taken for analysis, and four to six determinations of each were made. In each case there were at least three titrations which agreed within .1 cc. of about $\frac{N}{10}$ hydrochloric acid, so that the limit of error did not exceed 400 mg. of nitrogen when calculated to the entire bulk, and in mosts cases the error was less than half of that amount.

The difference in the weight of the air-dry sample and its weight after it was dried in a closed water bath for six hours and cooled in a dessicator represents the hygroscopic moisture. The weight of the air-dry soil, less the hygroscopic moisture, represents the weight of the water-free soil.

Conditions Affecting the Nitrogen Content of Arable Soils.

The nitrogen content of arable soils is subject to many changes, and may be affected by a number of factors. There are conditions which favor the accumulation of nitrogen in the soil, and there are conditions which lead to the dissipations of the soil nitrogen. The addition of nitrogen to the soil and its loss from the soil may take place at the same time, and the predominance of one or of the other can only be ascertained by the careful analytical study of small quantities of soil. Even then, the soil analyses may not show the exact influence of the several factors. The possible influence of these factors in the case of the cylinder experiments may be appreciated from the following considerations: The inert soil nitrogen contained in the organic portion of the soil is changed slowly. There is no doubt that the mineral portion of the soil exerts a great influence on this solution, and since the mineral salts contained in the several series are not exactly alike, because of the different treatments, their solvent action on the organic portion of the soil is variable. Where the mineral salts were applied together with the manure the relations are still more complicated. In the first place, there occur in the soil various processes of decay, during which some of the nitrogen is undoubtedly set free in the gaseous form, part of it as ammonia and part of it as elementary nitrogen. In the second place, there exists in the soil a number of organisms capable, under certain conditions, of fixing atmospheric nitrogen; moreover, some part, at least, is played

by the nitrogen brought down to the soil in atmospheric precipitation. Considering this at 5 pounds per acre, annually, there would be brought down on the three square feet of surface in each cylinder, in five years, about 3 gms. of soluble nitrogen. And, finally, the soluble nitrates are, in part, washed into the subsoil beyond the reach of the plants. It will be seen thus that the analytical results show only the algebraic sum of these influences. It is also evident that the relative influence of each of these factors is not the same in the several series. The amount of nitrogen lost from the soil by decay will depend on the kind and number of bacteria present in the soil, and these will be determined by the conditions of moisture, temperature and reaction of the soil, as well as by its content of soluble salts. Since these conditions vary in the several series, the extent of change and the amount of nitrogen set free in this change are also variable. The addition to the soil of manure will modify its temperature and moisture conditions; hence these will not be the same in series 7 as they are in series 12, for instance. Moreover, together with the manure, there are introduced into the soil great numbers of different bacteria, which will also affect the condition of the soil nitrogen. It is well known that in the nitrification of organic or ammonia nitrogen a portion of it is set free. The extent of the loss is quite variable. In the nitrification of ammonium salts it is slight; in the nitrification of organic matter it is greater, mainly because the process in the latter case is more complex. The extent of denitrification in the soil will largely depend on the amount of organic matter added to it in the manure. It is the purpose of the cylinder experiments to determine, among other things, whether denitrification really does take place in the soil when only ordinary quantities of manure are applied. As will be shown later, both the crop analyses and the soil analyses show that there was no denitrification. As to the fixation of atmospheric nitrogen by bacteria in the cylinder soils, it is difficult to determine at present. There are one or two instances which make it appear that there was some fixation there. It was already stated that the amount of nitrogen found in the soil represents the algebraic sum of the different gains and losses, viz., the manures and fertilizers applied, the atmospheric precipitation, the possible addition from the subsoil, the fixation of atmospheric nitrogen by bacteria, removal of nitrogen by crops, denitrification, various processes of decay, leaching action of rain, etc. All these factors make it difficult to determine with certainty whether any fixation does take place, unless such fixation is very considerable.

The Income and Oatgo of Nitrogen in the Different Series.

The amount of the nitrogen found to be present in the soil, the amount of nitrogen added in the manures and fertilizers and the amount of nitrogen withdrawn by the crop must all be considered in determining whether there was a loss or a gain of nitrogen in the course of the vegetation experiments. It was pointed out elsewhere that the factors which may lead to a decrease of the nitrogen store in the soil are numerous, and it was also noted that there are factors which may lead to an accumulation of nitrogen in soils even where no leguminous crops are grown. Under the conditions of the cylinder experiment, both in the lighter and in the heavier soil, there were very considerable losses of nitrogen. It will be seen from the analyses given below that, on the check plots, more than one-quarter of the nitrogen originally present was lost in the five years of the experiment. This fact shows unmistakably how the application of large quantities of acid phosphate and of muriate of potash affects the soil nitrogen in the course of a few years. The most important sources of loss were undoubtedly the draining away and the oxidation of the soluble nitrogen compounds in the soil.

Nitrogen in Shale Loam.

Cylinder Soils.

Series.	Nitrogen Originally Present. gms.	Applied. gms.	Removed. gms.	Present. gms.	Loss. gms.
1	156.15	.....	7.36	109.67	39.12
2	156.15	.....	7.67	104.68	43.80
3	156.15	20.19	11.77	119.97	44.60
4	156.15	22.68	14.56	123.65	40.62
5	156.15	18.07	11.28	130.03	32.91
6	156.15	20.56	11.97	127.89	36.85
7	156.15	4.69	10.20	112.58	38.06
8	156.15	7.80	12.33	114.00	37.62
9	156.15	24.93	13.93	126.99	40.16
10	156.15	27.99	16.68	126.99	40.47
11	156.15	27.37	18.29	124.38	40.85
12	156.15	30.48	20.18	128.53	37.92
13	156.15	22.76	13.43	129.63	35.85
14	156.15	25.87	15.84	134.32	31.96
15	156.15	25.25	13.93	130.20	37.27
16	156.15	28.36	17.29	125.98	41.24
17	156.15	8.03	11.40	110.60	42.18
18	156.15	7.79	10.65	110.97	42.32
19	156.15	26.10	14.67	132.42	35.16
20	156.15	25.86	13.48	130.32	38.21

The above analyses show that the soils of series 2, which received no application of combined nitrogen, but were supplied with an abundance of phosphoric acid and of potash, contain less nitrogen than the soils of series 1, to which nothing at all was applied. The difference is not due merely to the greater amount of nitrogen removed in the crops from series 2, but more largely to the losses that occurred in the soil nitrogen itself. There were present in 1898, 156.15 gms. of combined nitrogen in each cylinder of series 1 and 2. In 1902 the average amount of nitrogen in series 1 was 109.67 gms. per cylinder, and in series 2, 104.68 gms. per cylinder. During that time there had been removed from each cylinder in series 1, 7.36 gms. of nitrogen, and from each cylinder in series 2, 7.67 gms. of nitrogen. Allowing for the nitrogen thus removed, we find that there was a loss in each case of 39.12 gms. from series 1, and of 43.80 gms. from series 2. It thus appears that the addition of acid phosphate and of muriate of potash increased the loss of nitrogen from the soil to a considerable extent. It is quite evident that the losses were mainly due to the leaching out of the soluble nitrogen compounds, and the increased solution in series 2, over and above that in series 1, would naturally involve a greater loss. It does not follow, of course, that there is always a greater loss in the soils where a greater amount of soluble nitrogen is formed. Very often this increased amount of soluble nitrogen will be utilized by the growing crop without a corresponding loss appearing. The relations here will be determined by the initial development of the plants, and that, in turn, by the amount of soluble nitrogen present in the soil at the beginning of the season. With a plentiful supply of soluble nitrogen at this time the young plants are enabled to develop a vigorous root system, which will help them to utilize more thoroughly the soluble soil nitrogen as it is gradually formed during the season. Applying this reasoning in the case of series 1 and 2, we may come to the conclusion that in series 2 there was an accelerated solution of the soil nitrogen during the season, because of the presence of the acid phosphate and the muriate, yet the initial nitrogen was not sufficient to develop vigorous plants, and hence the weak growth could not thoroughly utilize even the little soluble nitrogen that was formed during the season.

The losses from the soils where fresh manures were applied are greater than those where the leached manures were applied. Thus, in 3 and 4 there were lost, on the average, 42.61 gms. of nitrogen, while in 5 and 6 there were lost, on the average, only 34.88 gms. of nitrogen.

This difference may be accounted for by the following: In the first place, the fresh manures contain more soluble nitrogen than the leached manures, and this soluble nitrogen is subject to leaching from the soil. In the second place, the fresh manures, because of their greater content of soluble nitrogenous material, are more fermentable than the leached manures, which had already undergone a partial fermentation. In the third place, the fresh manures, by their content of a more extensive and more varied bacterial flora, encourage a more rapid solution of the soil nitrogen, both directly and indirectly—directly through their bacterial hosts, indirectly by the chemical products formed in the decay of the manure. It is more difficult to explain why the loss of soil nitrogen was greater in series 3 than it was in series 4. It is possible, however, that the large amount of soluble nitrogen present in the solid and liquid manure of series 4 encouraged a vigorous initial growth, and consequently a more thorough utilization of the soluble soil nitrogen formed during the season. The correctness of this supposition is strengthened by the fact that there was considerably more nitrogen removed in the crop from series 4 than there was removed in the crop from series 3. Thus, in the crops from series 3 there were removed in all 11.77 gms. of nitrogen, while in the crops from series 4 there were removed in all 14.56 gms. of nitrogen. It appears that in most cases where such considerable differences exist the loss is smaller where the amount of nitrogen in the crop removed is greater. Thus, in series 8 there was more nitrogen removed than in series 7, and accordingly the loss of soil nitrogen was smaller in series 8. The same is true of 11 and 12, of 13 and 14, and of 19 and 20.

Comparing 5 and 6, we find that there were 20.56 gms. of combined nitrogen added to series 6, as against 18.07 gms. added to series 5. There were removed from series 5, 11.28 gms. of nitrogen, and from series 6, 11.97 gms. of nitrogen. This would indicate that the solid, leached, allowed a better utilization of the applied nitrogen than the solid and liquid, leached. According to the analytical data, there were present in the soil at the end of five years 130.03 gms. of nitrogen in series 5, and 127.89 gms. of nitrogen in series 6. The greater quantity of nitrogen applied in 6 gave but slightly greater returns than the smaller quantity applied in 5. With an allowance made for this, the loss is still greater in 6 than in 5.

Comparing series 7 and 8, we find that there were 4.69 gms. of nitrogen applied in 7, and 7.80 gms. in series 8. At the same time,

we also find that there were removed in the crops of series 7, 10.20 gms. of nitrogen, as compared to 12.33 gms. of nitrogen removed in the crops from series 8. Hence 3.11 gms. more of nitrogen was applied in 8 than there was applied in 7, while only 2.13 gms. more of nitrogen was removed. There was thus a better utilization of the nitrogen applied in series 7 than there was of the nitrogen applied in series 8. The soil analyses show, on the other hand, that there are present in the soil of series 7, 112.58 gms. of nitrogen, and in the soil of series 8, 114.00 gms. of nitrogen, indicating a smaller loss from series 7. The larger quantity of soluble nitrogen present at the beginning of the season in series 8 led to a better root development, and therefore to a better utilization of the nitrogen rendered soluble during the season's growth. While there may have been, thus, a greater loss of nitrogen from the nitrate on 8 during the earlier part of the season, there was a slighter loss from the soil during the latter part of the season. Similarly, the soils in series 7 and 8 are found to be richer in nitrogen than the soils in series 2, since the more extensive growth in the former series led to a more extensive transformation of the soluble soil nitrogen into the insoluble nitrogen of the underground portions of the plants which remain in the soil after the harvest, as well as the plant portions above ground removed in the harvest.

The soils in series 9 and 10 have the same nitrogen content, and the losses from the two soils were practically the same, since the greater amount of nitrogen applied in 10 resulted in an almost equal increase in the nitrogen of the crops removed. The average loss from series 9 and 10 is somewhat greater than the average loss from series 11 and 12. This shows that where the solid manure was used in combination it resulted in a greater loss of nitrogen from the soil than resulted in the series where the solid and liquid, fresh, was used in combination. The loss from the soils in series 11 was greater than that from series 12. In the former case there were applied 27.37 gms. of nitrogen, and in the latter case 30.48 gms. of nitrogen, a difference, in favor of 12, of slightly more than 3 gms. of nitrogen. The amount of nitrogen found in the crops from the two series were 18.29 and 20.18 for 11 and 12, respectively, a difference, in favor of 12, of slightly less than 2 gms. of nitrogen. The apparent greater loss of the manure and fertilizer nitrogen in 12 is due to the more extensive root growth and the better utilization of the soil nitrogen, so that, in series 12, there were found 128.53

gms. of nitrogen, and in series 11 only 124.38 gms. of nitrogen, thus indicating a loss of 20.85 gms. in series 11, and of 37.92 gms. in series 12.

The amount of nitrogen applied in series 13 during five seasons was 22.76 gms., the corresponding amount in 14 being 25.87 gms., or a difference of slightly more than 3 gms. in favor of the latter series. The amounts of nitrogen removed were 13.43 gms. and 15.84 gms., respectively, for series 13 and 14, or a difference, in favor of 14, of rather less than 2 gms. of nitrogen. Here, again, the greater amount of nitrogen applied did not show a proportionate return in the crop. On the other hand, the analyses show the presence, in the soils of 13, of 129.63 gms. of nitrogen, and in the soils of series 14 of 134.32 gms. of nitrogen. The loss from 13 was, therefore, 35.85 gms. of nitrogen, and from 14 only 31.96 gms. of nitrogen. Also here the greater amount of nitrate nitrogen led to a more economical use of the soil nitrogen, and decreased its loss from the soil.

A comparative study of 15 and 16 shows that a little more than 3 gms. of nitrogen were applied in the latter, and only 2.33 gms. more were removed in the crops. The soil analyses show the presence, in series 15, of 130.20 gms. of nitrogen, and in series 16 of 125.98 gms. of nitrogen, indicating a loss of 37.27 gms. of nitrogen in series 15, and a loss of 41.24 gms. of nitrogen in series 16. The relations here do not seem to be the same as in other series, and the greater amount of nitrate nitrogen in 16 did not lead to a better utilization of the soil nitrogen.

The average loss from series 9, 10, 11 and 12, where the fresh manures were used, was 39.85 gms. of nitrogen, and the corresponding loss from series 13, 14, 15 and 16, where the leached manures were used, was 36.58 gms. of nitrogen. Hence where the fresh manures were used, either singly or in combination, the losses were greater than in the soils where the corresponding leached manures were used. It has been pointed out above that the differences are probably due, not alone to the greater amount of soluble nitrogen compounds originally present in the fresh manures, but even more to the more intense fermentation process in the fresh manures, which, reacting on the soil, directly and indirectly hastened the solution of the inert soil nitrogen, and therefore involved a greater total loss from the soil. The amounts of nitrogen applied in series 17 and 18, respectively, differed but little; and the amounts removed showed a slightly better utilization of the ammonia nitrogen in series 17. The

amounts of nitrogen found in the two series were 110.60 gms. and 110.97 gms., respectively, for 17 and 18, thus showing a loss of 42.18 gms. from the former, and a loss of 42.32 gms. from the latter. These relations are brought out more clearly in the combinations of the ammonium sulphate and the dried blood with solid manure, leached. We thus find that there were applied in series 19, 26.10 gms. of nitrogen, and in series 20, 25.86 gms. of nitrogen. There were removed from the same series 14.67 gms. and 13.48 gms. of nitrogen, respectively. The amount of nitrogen found was 132.42 gms. in series 19, and 130.32 gms. in series 20, indicating a loss of 35.16 gms. in series 19, and a loss of 38.21 gms. in series 20. It appears from the above that the more soluble and more readily nitrifiable ammonia nitrogen protected more efficiently from loss the soluble soil nitrogen. Comparing the nitrate, ammonia and dried blood nitrogen used in combination with solid manure, leached, we observe the following:

Series.	Nitrogen Applied.
14........	Leached manure and 10 gms. of nitrate nitrogen.
19........	" " " equivalent amount of ammonia nitrogen.
20........	" " " " " " dried blood nitrogen.

Series.	Nitrogen Removed. gms.	Nitrogen Found in Soil. gms.	Nitrogen Lost. gms.
14......................	15.84	134.32	31.96
19......................	14.67	132.42	35.16
20......................	13.48	130.32	35.21

Evidently the nitrate nitrogen was not only more available than either the ammonia or dried blood nitrogen, but it also left the soil richer in nitrogen than did either of the two.

These results do not bear out the claim often made by practical farmers—that application of sodium nitrate seems to exhaust the soil—for the analyses show that soil to which nitrate had been applied is richer in nitrogen than the soil to which no nitrogen at all had been applied. This apparent contradiction is well explained by Wagner,[1] who states that the soil to which any nitrogen salt is applied, but not in excess, is poorer in soluble nitrogen, after the crop is removed, than a similar soil to which no nitrogen salt had been applied. The application of nitrate leads to a vigorous growth of the plants during the early stages of their development, and the

[1] Die Stickstoffdüngung der Landwirtschaftlichen Kulturpflanzen, p. 184.

vigorous plants are capable of utilizing more completely the soil nitrogen than similar plants which are not as vigorous. This is especially true where the soil itself is comparatively poor in soluble nitrogen at the beginning of the season, and where no excessive, but only comparatively slight, applications are made.

Many facts observed in practical agriculture, and hitherto obscure and often wrongly interpreted, are in agreement with these deductions.

Light applications of nitrate, applications which often did not exceed sixty pounds per acre, have led not infrequently to increased yields, which were greater than the nitrogen in the nitrate could produce. It has also been found that lighter applications of nitrate have produced a relatively greater increase, as compared to heavier applications, even in cases where not only the lighter, but also the heavier, applications of nitrate were so completely utilized by the plants that a state of nitrogen hunger became apparent in these cases. These phenomena may be easily explained by the fact that applications of nitrate may, under certain conditions, lead to a more thorough utilization of the soil nitrogen, and that this effect may be attained, at times, by relatively light applications of nitrogen. Yet this does not always hold good. When the soil is so poor in soluble nitrogen that a light application of nitrogen is insufficient to bring the crop to a point where it is in a position to utilize thoroughly the soluble soil nitrogen as it becomes available later in the season, a stronger application of nitrate may be relatively more profitable than the light application.

That the apparent diminution in the total nitrogen content of the soil where nitrate is used is due to the more thorough utilization of the soluble soil nitrogen, is also illustrated by the crop returns on our cylinder soils for 1899 and 1900:

Average Amount of Nitrogen in Crop.

Series.	1899 Main Crop—Oats. gms.	1899 Residual Crop—Millet. gms.	1900 Main Crop—Oats. gms.	1900 Residual Crop—Corn. gms.
1	0.789	1.000	1.108	0.858
2	0.831	1.052	1.152	0.794
3	1.106	1.582	1.589	1.157
4	2.938	1.558	2.370	1.114
5	0.996	1.398	1.447	1.158
6	1.455	1.269	2.043	0.991
7	1.422	0.878	1.797	0.731
8	1.901	0.854	2.335	0.774
9	1.505	1.487	2.116	1.177
10	2.260	1.661	2.719	1.223
11	3.635	1.598	3.124	1.114
12	4.022	1.834	3.623	1.178
13	1.413	1.199	1.987	1.243
14	2.064	1.292	2.496	1.172
15	1.978	1.296	2.347	1.143
16	2.596	1.347	3.297	1.097
17	1.645	0.948	2.198	0.748
18	1.457	0.961	1.929	0.834
19	1.825	1.245	2.288	1.147
20	1.650	1.352	2.204	1.193

We observe here the general tendency towards a decreased yield in the residual crop on the series where the more vigorous plant growth left but little soluble nitrogen in the soil at the end of the season. Thus, in 1898 there was a yield in series 3 of 1.106 gms. of nitrogen, and in series 4 of 2.938 gms. of nitrogen, in the main crop. In other words, the yield in series 4 was almost three times that in series 3. In the residual crop, on the other hand, the yield was 1.582 gms. in series 3, and only 1.558 gms. in series 4. Similarly, in 5 and 6 the yields were .996 gms. and 1.455 gms. of nitrogen, respectively, in the main crop, and 1.398 and 1.269, respectively, for series 5 and 6 in the residual crop. The same is also true of 7 and 8, and of 17 and 18. Where the nitrogen salts were used together with the manures, the yield, even in the residual crop, was greater where more plant substance was produced in the main crop. Thus, in series 9 the yield was 1.505 gms. of nitrogen in the main crop, and 1.487 gms. in the residual crop, while in series 10 the corresponding yields were 2.260 gms. and 1.661 gms. of nitrogen. It appears, then, that the more vigorous growth in series 10 did not

lead to a decreased yield in the residue. The same holds good in 11 and 12, in 13 and 14, and in 15 and 16. The different conditions here are due to the greater residual effects of the combined manure and nitrate nitrogen in the even series. At the same time, the very considerable differences in the main crop between the odd nitrate series and the corresponding even nitrate series become rather slight in the residual crop. Thus, in series 9 and 10 we find a difference of .755 gms. in the main crop, and a difference of .174 gms. in the residual crop. In 11 and 12 we find a difference of .387 gms. in the main crop, and a difference of .236 gms. in the residual crop. In 13 and 14 we find a difference of .651 gms. in the main crop, and a difference of .093 gms. in the residual crop. In 15 and 16 we find a difference of .618 gms. in the main crop, and a difference of .051 gms. in the residual crop. We also note a decreased difference in the residual crop where there is a greater difference in proportion to the total yield in the main crop. The same relation holds good, also, in the crops of 1900, with the difference that the more favorable seasonal conditions in 1900 made possible a more thorough utilization of the nitrogen in the soil by the main crop, and hence the yield was greater, on the average, in the oats of 1900 than it was in the oats of 1899. The average yield of nitrogen in the oat crop of 1899 was 1.874 gms. of nitrogen, and in the oat crop of 1900, 2.208 gms. of nitrogen.

Because of the more vigorous growth of the crop of 1900, we should expect slighter residual effects here as compared with the crop of 1899. As a matter of fact, this assumption is borne out by the results. We find in the residual crop a greater yield in series 1 than in series 2, a greater difference in the yields of series 3 and 4, of series 5 and 6, and of series 17 and 18. Moreover, we actually find greater returns in the odd combination series of the residual crop. Thus, in the residual crop of series 13 there is a greater yield than in the corresponding crop of series 14; and the same is also true of series 15 and 16.

The above results strengthen the conclusions drawn from the soil analyses, namely, that the presence of soluble nitrogen compounds at the beginning of the season allows a more economical use of the soil nitrogen, and that nitrate is of greater value in this respect than any other form of nitrogen, because of its greater solubility and the greater ease, therefore, with which it diffuses through the soil.

THE USE OF FERTILIZERS.

A REVIEW OF THE RESULTS OF EXPERIMENTS WITH NITRATE OF SODA.

1. *On Market Garden Crops, or Those of High Commercial Value.*
2. *On Field Crops, or Those of Low Commercial Value.*

The Use of Fertilizers.

Great gains have been made in the past few years in our knowledge of the necessity of using, and in the methods of use of, commercial fertilizers. A point of primary importance that has been learned is that their application is necessary for the most profitable culture of many of the crops grown, not only in the East and South, but also in sections of the country where it was formerly believed that the natural fertility of the soil would suffice for many generations. Their use has spread from the States of the East and South to those of the Middle and Northwest and Pacific slope—Wisconsin, Colorado, Minnesota and California now use many tons annually. The question as to the need of fertilizer settled, the next in importance is how to use the materials containing the essential plant-food elements in such a manner as to contribute to the best growth and development of the plants under the wide variety of conditions that exist, and thus secure the largest financial return from their application.

Nitrogen Should Receive Special Attention.

While the three constituents—nitrogen, phosphoric acid and potash—are all essential, because all are liable to exhaustion, nitrogen is the one that should receive more careful attention than the others, first, because it is the most expensive of the three to supply. Nitrogen is more expensive than either phosphoric acid or potash, largely because it costs more to produce it. The great natural deposits of phosphates in America and other countries make the possibilities of

their exhaustion very remote; besides, the comparative ease of mining, combined with the facilities with which these phosphates may be converted into superphosphates, materially reduces the cost of immediately-available phosphoric acid. In the case of potash, the vast deposits of Germany furnish unlimited quantities of crude material, which are readily converted into concentrated salts of potash, free from deleterious substances, and which furnish potash in immediately-available form, and, because of their high content of the essential element, the transportation charges are relatively low per unit of constituents. Nitrogen, on the other hand, is less abundant, and even though found in the form of nitrate of soda as a natural deposit, the quantity is limited in extent, as compared with the deposits of phosphates and potash salts. The location of the deposits in a barren country makes it more expensive, too, to concentrate and to remove impurities, and even when in its most concentrated commercial form, it is comparatively bulky, as compared with the manufactured potash salts, thus increasing the cost of transportation per unit of the constituent.

Second, because nitrogen exists in three forms—as organic matter, as ammonia and as nitrate—and which differ widely in their rate of availability or immediate usefulness to the plant. The nitrogen in the first and most common form (organic) generally undergoes a change into a nitrate before plants can make a large use of it; this change requires a longer or shorter time, according to the character of the material. If, therefore, we desire a large and reasonably quick use of the constituent when applied in organic materials, it is necessary, first, to select those likely to change rapidly, and second, to depend upon favorable weather conditions—*i. e.*, warm and moist—in order that a rapid change into soluble and available forms can take place, and thus permit the plant to obtain its nitrogenous food—that is, it is possible, in the use of these forms, which must undergo a change, to get very meagre returns, though an amount is applied largely exceeding that necessary for the crop, either because the nitrogen may have been in such combination as to strongly resist decay, or the season may have been such as to render the change, in even high-grade materials, so slow as to prevent the plant from obtaining a sufficient amount to meet its demands. The second, or ammonia, form of nitrogen is immediately soluble, and is readily distributed in the soil by means of the soil water; it is then fixed

until changed into the nitrate form, which takes place rapidly under average seasonal conditions, though an appreciable time must intervene between the date of its application and the time it can be used. In the case of the third form, the nitrate, no conditions modify its availability; it is readily soluble, and immediately distributes itself by means of the soil water everywhere in the soil, and as it comes in contact with the roots of the plants is at once absorbed by them, and continues to be absorbed until used up, or so long as there is sufficient moisture in the soil to cause activity in the plant itself. The availability of the nitrogen in the various materials may, therefore, range from practically nil to 100 per cent., making the matter of selection of material exceedingly important.

In the third place, because nitrogen, in this immediately-available form, is so readily soluble and so completely carried in the soil water, there is danger of its loss by leaching—that is, while there is no question as to the usefulness of this form of nitrogen—*i. e.*, nitrate—so far as its absorption by the plant is concerned, the best results are not always obtained from its use, because advantage is not taken of its peculiar and valuable characteristics; it is completely soluble in the soil water and distributes itself readily everywhere in the soil, and wherever it comes in contact with the feeding rootlets it is bound to be taken up, hence, when the applications are not properly adjusted, there may be an abnormal and inferior development of plant, because of too large a use of nitrogen, or, as it forms no fixed compounds in the soil, there may be a loss from leaching into the drains when applied previous to the growth of the plant or in too large quantities at the wrong time.

In the fourth place, it should receive careful attention, because its right use as a nitrate—its most available form—permits, not only an economical utilization by the plant, but a control of its growth; it may be used in such a way as to change the natural tendency, and thus improve it for specific uses; thus, in addition to the increase in yield which it may cause, it enhances its market value.

Potash and Phosphoric Acid Differ from Nitrogen.

As already pointed out, the mineral elements—potash and phosphoric acid—are relatively cheap as compared with nitrogen. In the case of potash, the availability of the different forms in which it is usually obtained is not a matter of great importance, since all forms are soluble in water, distribute freely in the soil and are readily absorbed by plants, while in the case of phosphoric acid the soluble and immediately-available forms contained in superphosphates may be obtained quite as cheaply as many of the insoluble forms, as animal bone and tankage, which are not so immediately useful; besides, these mineral elements, however soluble when applied, are fixed by the soil, and are thus not liable to rapid loss by leaching. When the farmer applies the "minerals," or materials containing potash or phosphoric acid in their best forms, his initial expenditure is not so great as for an equal amount of nitrogen; besides, he can depend upon their presence there during the growing season, and also that the plants can make use of the constituents; if the one season's growth of the plant does not use the entire amount supplied, the residues will remain for future crops, though they may be less readily acquired by them. These conditions are quite different from those obtaining when available nitrogenous materials are used, and are the basis of the suggestions frequently made to furnish the soil with an excess of the minerals, but adjust the nitrogen to the needs of the plant.

The Best Use of Nitrogen Requires an Abundance of Phosphoric Acid and Potash in the Soil.

A very important thing to remember in the application of nitrogen, however, is that, though it may appear very efficient, it cannot fulfill all the conditions of a complete fertilizer—it is not a complete food in itself; it is only an element of food, and its value as an element is measured largely by the content of minerals in the soil, with which it must associate and combine, in order to fully meet the food needs of plants. Hence, where nitrogen in any form is recommended as a fertilizer, it should be understood that the phosphoric acid and potash necessary for the growth of the crop must either be supplied with it, or have been previously applied, or should have existed naturally in the soil. On poor soils the applications must be made,

while in cases where the soil is naturally rich in minerals, if nitrogen only is added, the crops are largely increased, because, by virtue of the presence of nitrogen, they are able to gather the phosphoric acid and potash needed from the natural supplies in the soil, previously inaccessible to them, because of the deficiency in nitrogen. Under such circumstances, it is a commendable practice to use nitrogen only, as it enables a use of soil constituents, which are of no service while in the soil. The fear that such use of nitrogen will result in an undue exhaustion of phosphoric acid and potash, which is sometimes expressed, is not well founded, since, where an increase in crop is caused by the use of nitrogen only, the amounts of phosphoric acid and potash removed in the crop would be relatively greater than the amounts removed were some other condition responsible for the increased yield.

The chances of recovering, in the form of produce, the minerals used in excess are greater than are the chances of recovering all of the nitrogen used in excess of the needs of the plants, or even that used in moderate amounts, because of the differences in the fixing power of soils for the different elements when in a condition to feed plants. The nitrogen, when in its available form, the nitrate, does not form again any fixed compounds with the soil; hence, if the plant does not take it up, it may be lost by virtue of further changes of form, which results in its loss as a gas. This applies to the nitrogen in organic and ammonia forms, as well as to the nitrate. In the use of nitrogen, the aim should be to feed the plant; in the case of the minerals, excessive quantities may be used, as the accumulations are not liable to escape.

The Best Returns from the Use of Nitrogen Are Obtained When Applied to Good Soils, Well Prepared for Crops.

In the next place, the best use of nitrogen is attained when it is applied to soils in good condition, rather than to poor or worn-out soils. The soils to which high-grade fertilizers are applied should possess good absorptive and retentive properties, in order that the materials applied may be retained for the use of the crop, and the physical character also should be such as to permit a ready penetration of heat and an easy circulation of water—conditions which are essential in order that the activities within the soil may be unimpeded,

thus making it possible for the plants to easily obtain their needed food. In too many cases good plant-food is wasted because applied to mixtures of sand, clay and other materials, rather than to soils in the true sense, or to soils that have not been thoroughly prepared, the clods and lumps preventing a proper distribution of the material, as well as a ready absorption of moisture and free circulation of the plant-food.

The Kind of Crop an Important Factor in Determining the Agricultural Value of the Nitrogen.

Whether it will pay to use any one or more fertilizer constituents is a question that cannot be answered positively, except by the person who uses them. The relation of the cost of the fertilizer to the value of the increased crop is a variable factor, and, aside from weather conditions, is influenced by the availability of the constituents—that is, the proportion that a crop can obtain of the amount applied, the character and composition of the crop grown, and upon the market value of the crop. Because of the facts already pointed out in reference to the constituent nitrogen, viz., its cost, its variability in usefulness, and its liability to escape in the drains or air, it is of more importance than either of the other two in its bearing upon this point.

For example, the liberal application of materials containing nitrogen to crops which possess a low market value may result in a maximum production—that is, as large an increase in yield as it is possible to obtain—yet, because the nitrogen is so expensive, the value of the increased yield may not be equal to the cost of the nitrogen applied. On the other hand, its application to crops of a high commercial value, though not so completely used and not causing so large a proportionate gain in crop, may result in a large profit, because the cost of the nitrogen, though considerable, is relatively a small item when compared with the increased value of the crop obtained from its use.

It is shown in the experiments conducted with nitrate of soda, on different crops, that in the case of grain and forage crops, which utilized the nitrate quite as completely as the market garden crops, the increased value of crop, due to nitrate, does not in any case exceed $14 per acre, or a money return at the rate of $8.50 per 100 pounds of nitrate used, while in the case of the market garden crops

the value of the increased yield reaches, in the case of one crop, the high figure of over $263 per acre, or at the rate of about $66 per 100 pounds of nitrate. The nitrate applied was not better in the one case than in the other, but in the case of the bulky crops the plant required a larger amount of nitrogen to make a unit of crop than in the case of the market garden group; besides, it is a crop of low market value—dry hay will bring, say, $12 per ton, and a good yield is two tons per acre; the market garden group of crops show a high market value—succulent vegetables will bring as much per ton and the yield will be five to ten times as great. These relations of cost of material applied to value of crop are exceedingly important, and should be carefully looked into before planning for the purchase of materials.

Certain Crops are Especially Benefited by Nitrate Nitrogen.

In the next place, the form of nitrogen used is very important. Many crops, as, for example, those grown for early spring forage, or for hay or grain, as rye, wheat, timothy, orchard and other grasses, are unable to obtain the nitrogen from soil sources early enough to permit of a rapid and maximum development; the agencies which promote the activities which cause a change of organic forms of nitrogen into nitrates are dormant, hence an application of nitrogen in a completely-soluble and immediately-available form supplies the plant with what it needs at the time of its greatest need, and great gains in yield are made. In the culture of early market garden crops, too, or such as are improved in quality, and thus increased in value, by virtue of quickness of growth, the nitrate is of the greatest service. Such crops as tomatoes, cabbage, turnips, beet and others, in order to be highly profitable, must be grown and harvested early, as anyone can grow them in their regular season; their growth must be promoted or forced as much as possible in a season when the natural agencies are not active in the change of soil nitrogen into available forms, and the plants must, therefore, be supplied artificially with the active forms of nitrogen, if a rapid and continuous growth is to be maintained. Their edible quality is dependent, to a marked degree, upon this rapidity of development; hence a supply of plant-food in reasonable excess of ordinary demands is essential, in order that unfavorable conditions of season may, in part at least, be overcome.

Top-Dressings of Nitrate of Soda.

Owing to the fact that nitrate of soda is frequently used after the seed has germinated and the crop made a partial growth, this method of use is referred to as "top-dressing"—that is, broadcasting over the entire surface, or, in the case of hoed crops, alongside the row. This form of nitrogen is peculiarly adapted for this method of application, since it is so completely soluble that but a slight amount of moisture is necessary in order to distribute it throughout the soil, and, because of its ready availability, it is used by the plant as soon as it comes in contact with its roots. It is the only form that possesses both these characteristics, and is, therefore, to be particularly recommended for those crops which need an early and abundant supply of nitrogen.

Profits from the Use of Fertilizers.

The aim usually in the use of artificial fertilizers is to so supplement soil supplies of plant-food as to obtain a profit, and, as already intimated, the profits for the different crops will, to some extent, be in proportion to their economical use of the constituents applied. Still, one should not be deterred from the use of fertilizing materials, even if the conditions should render the application apparently wasteful, or a small recovery of the constituents applied, provided the increase in yield will more than pay the cost of the application. The farmer should calculate what increase in crop is necessary for him to obtain in order to make the use of fertilizers profitable, and if only this is obtained, he should not condemn their use. Many persons seem to have gotten the impression that there is some mystery connected with fertilizers, and that their use is a gamble at best, and are not satisfied unless the returns from the investment in them are disproportionately large. We very often hear the statement that, by the use of certain fertilizers, the crop is doubled or tripled, as if this were a remarkable occurrence and partook of the nature of a mystery. Such results are not mysterious—they can be explained; they are in accordance with the principles involved.

In an experiment on celery it was shown that the weight of celery from an application of 400 pounds per acre of nitrate of soda was two and one-half times greater than that obtained on the land upon which no nitrate was used, and that very great profit followed its use. This result, while remarkable in a way, was not mysterious;

if all the nitrogen applied had been used by the crop, there would have been a still greater increase. It simply showed that where no extra nitrogen had been applied the plant was not able to obtain enough to make the crop that the conditions of the season and soil, in other respects, permitted. In other words, that the soil did not contain a complete food; the nitrogen was necessary to supply the deficiency. Favorable conditions are, however, not uniform, and variations in return from definite applications must be expected.

It is quite possible to have a return of $50 per acre from the use of $5 worth of nitrate of soda on crops of high value, as, for example, early tomatoes, beets, cabbage, etc. This is an extraordinary return for the money invested and labor involved; still, if the value of the increased crop from its use was but $10, or even $8, it should be regarded as a profitable investment, since no more land and but little more capital was required in order to obtain the extra $5 or $3 per acre. It is the accumulation of these little extras that oftentimes change an unprofitable into a profitable practice.

PRACTICAL SUGGESTIONS AS A RESULT OF EXPERIMENTS.

I. FOR CROPS OF HIGH COMMERCIAL VALUE.

MARKET GARDEN CROPS.

It is well understood by all market gardeners that, in their business, liberal manuring must be practiced, and that the manures used must contain an abundance of nitrogen, that may be quickly used by the plant, if rapidity of growth and early maturity are to be attained. The experiments with nitrate of soda were, therefore, planned to show in which directions the benefits from its use were observed—whether, for example, in the larger yield of a crop of the same general character, or whether, together with the larger yield, there was an earlier maturity of those crops in which early maturity is an important factor, or whether the marketable quality was improved, thus returning a larger profit for the same yield, or whether all of these factors were involved, and the results showed that, as a whole, benefits were obtained in all these directions. The more important crops of this class were included in these experiments.

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EARLY TABLE BEETS.

In the growing of this crop, whose value may range from $300 to $600 per acre, the amount of plant-food annually applied is usually far in excess of that removed in the crops of any year, in order to guarantee against any shortage of food should unfavorable weather conditions intervene; the crop must be kept growing at all hazards. In good practice an application of from fifteen to twenty tons of manure and about one ton of a high-grade commericial fertilizer are used per acre. The plants are usually grown under glass, and transplanted as soon as the land is fit to work. Hence the questions asked by the experimenter were, first, whether an additional application of nitrogen in the form of a nitrate would be a profitable practice in connection with this heavy application of all of the plant-food constituents, and second, how much should be used. The applications, therefore, ranged from 400 to 700 pounds per acre. The results from the experiments of two years were emphatic in showing an increase in yield and a considerable profit each year, and though the profits were not in proportion to the amount of nitrogen applied, the largest net returns were obtained from the heaviest applications; the average net return per acre from 400 pounds was $24.40, and from 700 pounds, $47.55. The influence of the nitrate was noticeable mainly upon the earliness of crop. In the first experiment the yield of the first picking was 63 per cent. greater from the nitrated plots than from the one upon which no additional nitrate had been added. The extra early yield, for which the highest prices were obtained, was increased from 8.3 per cent. on the plot on which 400 pounds were added to 12.8 per cent. on the plot which received 700 pounds per acre, an increased yield at a less cost per unit of harvesting—points of great importance.

Method of Using the Nitrate.

The amount used may range from 400 to 800 pounds per acre, depending upon the conditions, always remembering that the richer the soil and the better its condition the larger will be the amount of nitrate that can be used to advantage. The beets are usually transplanted, and one-half of the amount of nitrate of soda used

may be applied either before transplanting (as the danger of leaching will not be serious) or immediately after, and in about three weeks the balance may be applied. In applying nitrate after the plants have made considerable growth of top, care should be taken to distribute it as near as possible between the rows, or, if broadcasted, only when the leaves are perfectly dry, so that all of the salt may reach the soil, and thus not be liable to injure the plants. Where it does not seem practicable to make the application of nitrate of soda separately, then the nitrate, in the quantity desired, may be mixed with the commercial fertilizer and all applied at the same time. This practice saves labor and danger of injuring the foliage, though it may result in a slight loss of the nitrate, as it should be applied long enough before the plants are set to permit of its thorough distribution in the soil. Still, the danger of loss is not great, unless the season is so extremely wet as to prevent cultivation.

ASPARAGUS.

In the case of asparagus, which is a perennial, the final results of the experiments have not yet been secured, though the experience of practical growers is unanimous in favor of its use. This crop, as is the case with early beets, requires heavy manuring or fertilizing, or both, for the highest profit. The advantage of the extra dressings of nitrate of soda over other forms of nitrogen lies chiefly in the fact that it may be appropriated immediately, either for supplying the needs early in the season or to stimulate the growth of tops after cutting has ceased and the crowns exhausted. Where manure is used alone in liberal amounts, the top-dressing with nitrate would not be likely to be so useful an adjunct as where commercial fertilizers, containing high percentages of minerals, have been used, as it must be remembered here, as always, that nitrogen is not a complete food, but an element of food, and cannot exert its full effect except in the presence of the necessary supply of the mineral elements.

Methods of Using Nitrate.

In the early spring, as soon as the land is fit to cultivate, the beds are plowed or cultivated, throwing the earth away from the crowns, and commercial fertilizers, rich in nitrogen—5 to 6 per

cent.—are applied, over the row, at the rate of 800 to 1,000 pounds per acre. The fact that asparagus is a perennial, and the growth in the spring depends largely upon the food stored up in the roots in the fall, the effect of the spring application is not so noticeable in the early cuttings, but materially benefits the later cutting. Commercial beds are usually cut for about two and one-half months, and this long period of continuous removal of shoots reduces the vitality of the crowns, and because the vigor of growth and size of the tops measures, to a marked extent, the size of the next crop, as soon as cutting is finished from 250 to 400 pounds per acre of nitrate of soda should be applied. The roots immediately absorb this available form of nitrogen, which stimulates and strengthens the plant, and enables it to appropriate the excess of minerals which have been applied, and, as a consequence, a large, vigorous and healthy growth of top is made, which not only results in storing the food in the roots for use the next season, but it enables the plant to resist the ravages of the rust. There is no other form of nitrogen that can be used or other means by which this object can be so readily accomplished as by a liberal supply of nitrate of soda, and the result is, not only a larger yield, but a greater proportion of large shoots, which increases the market value of the crop; the growers who practice this system have no difficulty in contracting their entire crop from year to year at very remunerative prices.

EARLY TOMATOES.

A careful study of the special needs of plants shows that there is no other one crop that responds more favorably to the use of immediately-available nitrogen than early tomatoes. The influence of the use of nitrate is not only shown in the increase in the yield—in some cases practically doubling it—but in the improved quality of crop, and because of the larger crop an increased maturity is virtually secured. These are all points of extreme practical importance. The results of all the experiments conducted in different parts of the country and in different seasons show an average gain in yield of about 50 per cent., with an average increased value of crop of about $100 per acre.

Methods of Practice.

In the growth of this crop two methods are used, depending largely upon the character of the soil and its previous treatment in reference to commercial fetilizers or manures. In the first, where the farmyard manure and commercial fertilizers, rich in minerals, have been used on previous crops, then nitrogen in the form of nitrate only is used, and the application ranges from 150 to 250 pounds per acre. By this method the yields are not so large, but the crop is usually earlier, and the net profit is quite as great as if larger applications of manure or fertilizer were made at the time of setting the plants. The object is early tomatoes, and, under average conditions of season and markets, any application of fertilizer or any practice which would tend to encourage a later growth or longer season would reduce proportionately the net profits.

In the other method, farmyard manures are usually spread upon the soil in the fall or winter, thoroughly worked into the soil in the spring. A fertilizer containing chiefly phosphoric acid and potash is applied broadcast previous to setting the plants, and at the time of setting an application of 100 to 150 pounds per acre of nitrate of soda is applied around the hill or over the row. After two or three weeks, depending upon the season and the relative growth of the plants, another application of nitrate of soda at the same rate is applied. This, because it minimizes the interruption in the feeding of the plant by furnishing immediately-available nitrogen, causes not only an increase in the yield and marketable quality of the entire crop, but it materially increases the quantity of early fruit. The results of four years' experiments show that, by this method, the value of the increased yield of what may be regarded as extra early fruit averaged about $45 per acre.

How to Apply Nitrate.

As in other cases, care should be used in the application of nitrate; it should not come in too close contact with the plants, and, if broadcasted after the plants are set, it should be done when they are dry, so that all of the nitrate may reach the soil. Where a larger quantity is used, as, for example, 300 pounds or more, it is very desirable that

fractional dressings should be made, though care should be used not to make the second application too late, as it encourages a later growth of plants and retards maturity.

EARLY CABBAGE.

The cabbage is a gross feeder, and the crop can utilize large quantities of plant-food to good advantage. The experiments with this crop show that even where the land has been fertilized with what would be regarded as reasonable amounts of fertilizers adapted for the purpose, extra dressings of nitrate have given very profitable returns. The yield has been increased from 40 to 80 per cent., and the net value of crop from $53 to $80 per acre. The experiments also show that what may be regarded as a large quantity of nitrate, namely, 400 pounds per acre, is superior to any smaller quantity, and further, that this would better be applied in two rather than in a greater number of fractional dressings, as the later applications have a tendency to disproportionately increase leaf growth and retard heading. The most remarkable effect of the nitrate is shown in the influence it exerts upon the marketable quality of the crop. In the experiments conducted the addition of nitrate resulted in more than doubling the value of those heads which were marketable—that is, where no nitrate was applied, $1 per hundred was received, and where 400 pounds of nitrate was used the price was $2.50 per hundred. These results suggest a reason for the lack of success of many growers, who depend solely upon applications of mixed fertilizers.

Methods of Application.

On soils well adapted for the crop—medium sandy loams—the land should be plowed early and well cultivated. If manures are readily attainable, a dressing of ten tons per acre may be applied and well worked into the soil; previous to setting the plants a fertilizer rich in nitrogen, one containing 6 to 7 ammonia, 6 to 8 phosphoric acid and 6 to 8 potash, should be applied, preferably broadcast, at the rate of 800 to 1,000 pounds per acre. At the time of setting, or very shortly after, nitrate of soda, at the rate of 200 pounds per acre, should be applied, preferably along the row, and cultivated in; this followed two or three weeks later with a second dressing of 200

pounds. The effect of these applications—that is, the presence of an abundance of available nitrogen—will be to stimulate and strengthen the plant, so that it will make use of all of the other food in the soil, and be able to overcome, in a great degree, any unfavorable conditions that may prevail later in the season. The natural tendency of the plant to absorb food is gratified, and a maximum crop is the result.

EARLY TABLE TURNIPS.

This is a crop of very considerable importance in market garden districts, and in certain sections is very profitable. The profit, other things being equal, is measured by the earliness with which the crop may be gotten into the market. Owing to the fact that the crop is planted very early, often before the weather is settled, heavy dressings of soluble nitrogen at time of planting would be liable to considerable loss from leaching. Hence fractional dressings have proved the most satisfactory. The gains obtained in the experiments from the use of nitrate have ranged from 30 to over 100 per cent., according to the amount applied and method of application. The increased value of crop, due to the nitrate, averaged about $30 per acre—a very handsome return from the use of the extra fertilizer.

Methods of Application.

Where soils have been previously liberally fertilized, particularly with the mineral elements, the recommendations for fertilizers, which have in practice proved very satisfactory, are as follows: Prepare the soil early and apply a light dressing of manure, either previous to plowing or after plowing, and harrow in well, and apply a commercial fertilizer rich in minerals, say, with a composition of 2 per cent. nitrogen, 8 per cent. phosphoric acid and 5 per cent. potash, at the rate of 1,000 pounds per acre. After the plants have germinated and well started apply, broadcast, 150 pounds per acre of nitrate of soda, following this in two or three weeks with a second application of 150 pounds. The first dressing will serve to stimulate leaf growth and a deep penetration of root, and the second dressing will encourage a rapid growth of the turnip, so necessary if high quality is to be obtained. Applications made later than one month after the seeding

usually encourage too large a leaf growth, thus reducing the yield of early crop. In the experiments three equal dressings of 133 pounds each reduced the yield by over 3,000 pounds per acre below that which was obtained in two equal dressings of the same amount as suggested herewith. The effect of the third dressing seemed to be to induce growth of top rather than root. The increase in the maturity—that is, the quantity of early crop—will be directly increased, in so far as the nitrate induces a larger crop, which is one of the first results of its application.

SWEET CORN.

Very great progress has been made in the growth of sweet corn for the early market, due both to the development of hardier varieties and to greater care in the selection and use of fertilizing materials. These hardy varieties of sweet corn are now frequently planted as early as March as far north as New Jersey, and, when planted so early, the soil supplies of nitrogen are yet unfavorable for the change of organic or other forms of nitrogen into the nitrate form. Hence nitrate should constitute a large part of the nitrogenous food of the plant if early maturity is to be accomplished. Owing to this fact, the utilization of the nitrate by the plant is liable to be less than if applied later, as the season for heavy rains, which are liable to carry away part of the soluble nitrogen, is not yet over, besides, the weather is not warm enough to cause a rapid growth. Practice, however, has shown that, by small fractional dressings of nitrate early, maximum results may be obtained. In the preparation of the soil for the growth of this crop, therefore, considerable organic nitrogenous material may be used to advantage.

Methods of Practice.

A good practice is to manure the soil, either during the fall or winter, with from ten to twelve tons per acre, apply previous to planting or setting the plants (in many cases the plants are started in the plant-house), a fertilizer rich in phosphoric acid and potash, also containing organic forms of nitrogen, and use a compost in the hill at time of planting, and use the nitrate as a side dressing after the

corn is well rooted. The advantage of the compost and organic forms of nitrogen is that they supply the soil with an abundance of readily-fermentable material, which, to some extent, warms the soil, besides containing substances useful in later stages of growth. Nitrate may be applied in three dressings, at the rate of 100 pounds per acre in each dressing, and the dressings should be so distributed as to cover the season of growth—that is, as soon as plants begin to form ears the last application of nitrogen may be made, which encourages a quick growth of the ears and also makes them much larger. The increased gains per acre when the nitrate has been used in this way have ranged from $18 to $40—a very profitable use of nitrogen, as the gain is really in excess of that which would be obtained by average methods of manuring.

MUSKMELONS.

Soils suitable for the growth of muskmelons are preferably light, sandy loams, not naturally well supplied with any of the constituents of plant growth. The crop does not require large quantities of plant-food, but must have the needed amount in available form early in the season. Experiments that have been conducted through several seasons show that the best form of nitrogen for this crop is the nitrate, and that preferably two applications should be made. The increase in yield from the addition of nitrate of soda has averaged, practically, 100 per cent., with an average increased value of crop of $100 per acre. It is shown, further, that as in the case of very early crops, that the earliest ripened fruit is not found upon the plants which received the extra fertilizer, but rather upon those insufficiently nourished, and thus forced to maturity because of a lack of food; besides, these specimens are usually small and of poorer quality. The increased value is obtained because of a large crop of finer quality, as a very marked influence of the added nitrogenous substance is noticed in marketable quality of the total crop, reducing very materially the percentage of culls. The experiments showed that, while the percentage of culls, where no nitrogen was applied, averaged 40 per cent., the average per cent. of culls on the fertilized area was but 25 per cent., indicating that the normal development of fruit requires a sufficient abundance of available nitrogen.

Methods of Practice.

On light soils, apply broadcast during fall or winter, 8 to 10 tons of manure, which should be plowed in early in spring. After the land is prepared, a high-grade fertilizer should be applied broadcast, at the rate of 600 to 800 pounds per acre, and harrowed in previous to planting. After the plants are well started, apply 100 pounds per acre of nitrate of soda; before the vines begin to run, make an additional application of 100 pounds per acre. Care should be taken in the application of the nitrate, as suggested in the case of the other crops, not to allow the salt to come in contact with the foliage of the plants.

CUCUMBERS.

In the case of cucumbers, heavier soils may be used, and larger quantities of fertilizers applied. In our experiments, the application of nitrate in addition to regular methods of fertilization resulted in a very large increase in crop—over 100 per cent.—and an increase in net value of over $60 per acre. The amounts of nitrate applied may range from 250 to 350 pounds per acre, and it should preferably be distributed more evenly throughout the season than in the case of the melons; 300 pounds per acre, in three applications, gave the best results. The effect of the nitrate here, as in the case of melons, was particularly noticeable in maintaining a rapid and continuous growth of vine and fruit, thus materially reducing the proportion of culls. For growing this crop to best advantage, the soil should either be well manured or a commercial fertilizer, rich in all of the constituents, should be applied at the rate of 400 to 600 pounds per acre, previous to planting; and after the plants have well started, 100 pounds per acre of nitrate of soda should be applied; this to be followed with two further dressings of the same amount. The time between the dressing may range from two to three weeks, according to season.

CELERY.

Celery is a crop that responds most profitably to an application of an abundance of available nitrogen. This fertilizer not only increases the yield, but very materially improves the quality of the crop. Where

the soil is naturally rich, or where what may be regarded as good methods of practice, in reference to fertilizers, are followed, extra applications of nitrate result in very largely increased yields and proportionate improvement in quality. In the experiments that were conducted, it was shown that where ordinary treatment was given, and a small and unprofitable crop was obtained, the addition of a few dollars' worth of nitrate changed the crop into a very profitable one; and in the case of a soil that was regarded as good enough to produce a fair crop, the addition caused a large increase in total crop, and a very marked improvement in the quality. The selling price of roots grown with nitrate was 150 per cent. greater than where none was applied, and 100 per cent. greater than where an insufficient amount was used. The increased value per acre of the crop from the best use of the nitrate was over $250.

Methods of Application.

The celery crop is expensive, both in plants and in labor, and since the cost of these items is the same whether the crop is large or small, intensive systems of feeding the crop usually give excellent returns. The crop is also very much improved in quality if the conditions are made favorable for continuous and rapid growth, hence an abundance of moisture and of immediately available food are prime essentials. The former can be controlled to a large extent by good methods of culture, but the best culture of the best soils is not capable of providing the necessary food, and, of the essential elements of food, nitrogen seems to be the one that contributes especially to rapidity of growth and to the formation of stalk which possesses that peculiar crispness which in so marked a degree measures marketable quality. Soils that are deep, moist and rich in organic matter are best suited for the crop; these should be heavily manured, say, at the rate of ten to fifteen tons per acre, and should also receive liberal amounts of high-grade commercial fertilizer, at the rate of 600 to 800 pounds per acre, all applied broadcast previous to setting the plants. After the plants are well started, apply 200 pounds per acre of nitrate of soda along the row, and, if the weather is dry, cultivate it in, though, ordinarily, the moisture in the soil is sufficient to cause an immediate distribution of the salt; and in three to four weeks make a second application of nitrate of the same amount and in the same manner. The two ap-

plications of nitrate, of 200 pounds each, will, it is believed, give, on the average, better returns than smaller amounts or a greater number of applications, though the conditions of season may warrant such changes from this method as the judgment of the grower may dictate.

PEPPERS.

The growing of peppers has become a considerable industry in market garden districts in recent years. Studies of the special needs of the crop show that, on good soils, well adapted for the plant, additional dressings of nitrate are necessary for best results—the gain in yield averaging 35 per cent., and the increased value of crop due to the added nitrates averaging $30 per acre. A large quantity—300 pounds per acre—seems to be much superior to any less amount, and, owing to the fact that peppers continue to form during the entire period of growth, the distribution of the nitrate throughout the season is desirable where large quantities are applied. Where more convenient the first application of nitrate may be applied at time of setting the plants, in order to prevent any delay in growth after setting. The later fractional applications are distributed throughout the season, two or three weeks apart.

EARLY POTATOES.

In the growing of early potatoes it is essential that an abundant supply of nitrogen be at the disposal of the plant. The experience of growers has clearly demonstrated this fact, and, until commercial fertilizers came into general use, most growers used large quantities of yard manure, in order that the plant should suffer no lack of this element. With the introduction of commercial fertilizers, the question of greatest importance has been the source of nitrogen best suited to meet the demands of the special early growth. The experiments which have been conducted with a view to answering this question have shown clearly that while nitrate is most useful, a combination of the nitrate with quickly-available organic forms, as dried blood, or with both organic and ammonia forms, is preferable to the use of any single form.

Methods of Practice.

On good potato soils, therefore, a good fertilization should consist of from 800 to 1,000 pounds of a fertilizer containing nitrogen, 4 per cent.; available phosphoric acid, 8 per cent., and potash, 10 per cent; one-third of the nitrogen at least to be derived from nitrate of soda and the remainder from quickly-available organic forms. On soils in good condition the fertilizer may be applied in the row at the time of planting, though many prefer to apply one-half of the desired amount broadcast previously and the remainder in the row with the seed. Where there appears to be a deficiency of nitrogen, due to the fact that nitrates have been carried to lower levels by rains, or to the fact that the season has not permitted the change and appropriation of organic forms, then the application of 100 pounds of nitrate per acre at the time of blossoming will encourage the rapid growth of tubers, though retarding, to some extent, the time of ripening.

SWEET POTATOES.

The sweet potato finds its most congenial home in a light, sandy soil. The physical character of the soil measuring, to a large extent, the quality of the crop, though the method of fertilization will also influence this to a certain extent. This plant seems to have the power of acquiring from the soil nitrogen that is inaccessible to other plants, and thus, where large applications of this element are made, a tendency to undue vine growth seems to be encouraged, and also to change the marketable quality of the tubers, causing a long, rooty growth, rather than a compact, nodular form. The use of a small amount of nitrogen is, however, desirable, an increase of from fifty to seventy bushels per acre being secured from such use. Hence, soils rich in nitrogen, or those upon which nitrogen has been previously applied in considerable quantities, do not produce tubers of the character demanded by our northern markets—a small, round tuber, which cooks dry and has a nutty flavor. These characteristics of quality cannot be secured in crops grown on heavy soils, nor on sandy soils too liberally supplied with nitrogen.

Methods of Practice.

The fertilizer may be applied at the time of making up the rows, in order that it may be evenly distributed before the slips are planted. This will encourage immediate growth of plant, and the small quantity of nitrate which is applied early in the season will not militate against the proper development of the tuber, as an absence of nitrogen in the soil after the nitrate has been taken up will discourage the formation of the rooty form of tuber, which is marketable at a lower price.

Experiments have also demonstrated the necessity in the soils of an abundance of minerals, and a fertilizer containing 2.5 per cent. nitrogen, 7 per cent. available phosphoric acid and 10 per cent. potash, one-half the nitrogen to be drawn from nitrate, seems to meet the requirements better than one containing a larger amount of nitrogen.

2. FOR CROPS OF LOW COMMERCIAL VALUE.

Hay and Grain.

The growth of hay and the cereals, wheat and rye, forms a very important part of the farming interests of the Eastern, Middle and Southern Coast States. The areas of these crops in eighteen States, including Tennessee and Kentucky, are, in round numbers, as follows:

Hay	15,000,000	acres.
Wheat	8,000,000	"
Rye	772,000	"

In most of these States large quantities of commercial fertilizers are used, either because the soils are naturally poor or because they have been depleted of their original constituents by continuous cropping, and, even with added fertilizers, the yields are not large enough to make the crops in themselves highly profitable. In many States the yield in particular districts is large, but the average yield of hay is but 1.25 tons per acre; of wheat, but 13 bushels per acre, and but 15 bushels of rye. The aggregate production of these crops is, however, very large, and, because of the conditions which prevail, it is likely that their growth will continue for some time to come, though it is eminently desirable that the average yield should be increased.

One of the chief reasons for the low average yield is that the farming is on the "extensive," rather than on the "intensive" plan. The relatively large areas used are not well prepared for the seed, and the fertilizers applied do not fully supplement soil supplies of plant-food. These conditions, too, are not liable to change at once, because the farmers are not yet prepared to adopt the more rational intensive system; the adjustment to new conditions requires time. The suggestions here given as to the use of top dressings of nitrogenous substances are therefore of primary importance, because, if followed, it will enable the farmer to obtain more profitable crops, and will encourage the gradual adoption of better systems of practice.

The farmers have, however, reached the point where they are asking the general question: "How shall I profitably increase the yields of these crops?" They are not satisfied with present conditions, nor with the general advice to supply the crops with additional plant-food. The advice is not definite enough, and they are not sure that the cost of expensive plant-food will be returned in the immediate crop, and they cannot afford to wait for future crops to return an interest on the invested capital. As soon as it is made clear that a profitable increase in crop from the use of fertilizers is a reasonable thing to expect, then the questions are—*first,* "What shall I use?" *second,* "How much shall I use per acre?" and *third,* "When and how shall it be applied?" Experiments that have been conducted with the use of nitrate of soda answer all of these questions in a definite and specific way.

HAY.

In the case of hay, from timothy and other grasses, the experiments that have been conducted answer the first question—"What shall I use"—as follows: Use nitrate of soda, because it is a food element that is especially needed; it is soluble in water and can be immediately taken up by the plants and supply them with that which they need at the time they need it—it can be used by them early in the spring before other forms of applied nitrogen are usable and before other soil supplies are available. The results of experiments conducted through a period of nine years, and in different sections of the State, show that upon soils which will produce crops ranging from one to three tons per acre, a gain in yield of from 9 to 54 per cent., or an average increase of 32.7 per cent., may be expected from the use of from 100 to 150 pounds

per acre, which would show an average gain in yield of 654 pounds per acre; based on the average yield of this section of the country of 1.25 tons per acre, the gain would be 820 pounds. This increase, at an average price of $12 per ton, would mean about $5 per acre, or $2 more than the cost of the material. A very satisfactory profit, when it is remembered that it is obtained at the same cost of labor and of capital invested in land.

How Much Shall Be Applied.

The second question, as to how much shall be applied, experience teaches that on good soils, in a good state of cultivation, 150 pounds per acre would be regarded as the most useful amount, though on poor soils, 100 pounds would be better, and on richer soils, as high as 200 or 250 pounds per acre may be used with advantage. The reason why a smaller amount is recommended on poor soils is because on such soils there is liable to be a deficiency of the mineral elements, and inasmuch as the nitrate is not a food complete in itself, but an element of food, the plant would be unable to utilize it to the best advantage in the absence of the necessary minerals. Where the soils are good, or under the intensive plan, larger amounts may be used, as under this system all the constituents are supplied in reasonable excess, besides every precaution is taken to have the physical condition of the soil so perfect as to provide for the easy distribution and absorption of the food applied. In experiments conducted in Rhode Island, the largest profit was obtained from the application of 450 pounds per acre, together with the necessary minerals. This method of practice is one which should be the ultimate aim, and can be accomplished by gradually increasing the amounts as the profits from the crops grown from the application of smaller amounts warrant.

Methods of Application.

The experiments, the results of which are confirmed by experience, also answer the third question, as to when it shall be applied. Apply as a top-dressing in spring, after the grass has well started, when the foliage is dry, and preferably just before or just after a rain. If applied earlier than this there will be a slight danger of loss, because the roots will not be ready to appropriate it, and, as it is entirely

soluble, it may be washed into the drains. If applied when vegetative functions are active, it is immediately absorbed, and stimulates and strengthens the plant not only, but causes it to throw its roots deeply into the soil and to absorb more readily the mineral food, and thus utilize to a fuller degree the amount of nitrate applied. It has been shown that, even under the best seasonal and soil conditions, a part of the nitrate will disappear in any case, and that only about 75 per cent. can be expected to be returned in the increased crop, and if this 75 per cent. is all returned in the crop, a maximum of about 1,500 pounds would be produced if the yield only was increased. Frequently, however, not only is the yield increased, but the quality of the hay is improved—that is, there is proportionately more nitrogenous substance in the hay than in that obtained where no nitrogen has been used, so that, unless the nitrate has been absorbed uniformly, we cannot expect the yield that may be calculated from the amount of nitrogen applied. These experiments suggest, further, that, owing to the difficulty of evenly distributing a small amount of nitrate of soda, and owing, also, to the fact that, on soils that have been seeded with grass, there is frequently a deficiency of mineral elements, a mixture may preferably be used which is rich in nitrate, usually one-half, the balance consisting of acid phosphate, ground bone and muriate of potash. The soluble minerals are readily carried to the roots of the plants, and the ground bone feeds the surface roots, and the nitrate is absorbed quite as readily as if not used with any other material. This method is to be recommended whenever the land is in good condition, and it is desired to keep up the content of the mineral constituents in the soil, as well as to avoid any danger of overfeeding with nitrogen, which would have a tendency, particularly in the warmer climates, of causing a softer growth and formation of mildew. This is liable to occur where the nitrogen is in excess and the ration is not well balanced. A good mixture for top-dressing may be made up as follows:

Nitrate of soda	500 lbs.
Ground bone	200 "
Acid phosphate	200 "
Muriate of potash	100 "

Applied at the rate of 200 to 300 pounds per acre.

WHEAT.

The answer to the questions as applied to wheat are, in essence, the same, though modified in particular points, owing to the fact that the wheat is grown for grain, rather than for weight of total produce, as in the case of hay, and also because wheat, being seeded in the fall, has not so large a root system as the grass, and therefore greater care should be used in the application of the material. Nitrate of soda is, however, the substance that is likely to give the most satisfactory results as a top-dressing, because, as already pointed out, it is soluble, and can thus reach every point of the soil without the necessity of cultivation and it is immediately available, and thus supplies food at once or at the time most needed, stimulating the plants weakened by the winter and strengthening those already vigorous, and enabling them to secure a larger proportion of the mineral elements. The time of application should be early in spring, or after growth has started.

Gains from the Use of Nitrate of Soda.

The results of experiments conducted to answer this question show a gain in both grain and straw from the top-dressing of nitrate of soda. The yields per acre, without the top-dressing, ranged from eleven to twenty-seven bushels of grain per acre and from 1,500 to 1,800 pounds of straw, thus showing a wide variation in the character of the soils used and in seasons, making the average of the results generally applicable.

The gain in yield of grain ranged from 25.9 to 100 per cent., while that of straw ranged from 54 to 100 per cent., or an average of 60.8 per cent. increase in the case of the grain, and 83.8 per cent. increase in the case of the straw. The value of these increased yields, at average prices, shows a large profit in all cases. Applying this to the average yield per acre of wheat and straw, namely, thirteen bushels of wheat and 1,600 pounds of straw for the Eastern and Southern States included in our discussion, we find a gain of 7.9 bushels of wheat and 1,340 pounds of straw, and a valuation of seventy-five cents per bushel for wheat and $6 per ton for straw, which prices probably represent the average, though not as high as are now prevailing, the total value of the increase is $9.95, or a net gain of $6.20 per acre,

using the high price of $50 per ton for the nitrate of soda. The profit here indicated is a good one and would make wheat raising more encouraging, besides stimulating the farmer to better practice in other directions. The calculated yields from the use of nitrate are not unreasonable to expect, since on good wheat soils and with fairly good management, without the additional nitrate, the average yield is over twenty bushels per acre.

The Amount to Apply.

In reference to the second question, as to how much nitrate shall be applied, the experiments show that on soils in a good state of cultivation those that will produce from, say, fifteen bushels per acre, without top-dressing, 150 pounds per acre, the average amount used in the experiments, would be the most useful, though, on poorer soils, which would average ten to twelve bushels per acre, 100 pounds would be better, for the reasons already discussed in the case of hay.

On better soils, where quantities larger than 150 pounds per acre seem desirable, it is strongly recommended that two applications of equal weight be made; the first, when the plants have well started, and the second, when the crop is coming in head. Very often the season is such as to encourage a rapid change of the insoluble nitrogen in the soil, in which case too large an application in the spring would tend toward an undue development of leaf and the ripening would be impaired, hence the advantage of dividing the amount is apparent, as, if the season is good and the growth normal, the second application may be dispensed with. Where the soil is liable to be deficient in minerals, and this is often the case, the nitrate may be mixed with other materials, as recommended for hay, the excess of minerals not used for the wheat providing for the following crop.

RYE.

The three experiments with rye in 1894 confirm the conclusions reached in both the experiment on hay and wheat, that nitrate of soda as a top-dressing proves desirable in effectually increasing the yield of both grain and straw, and which is accomplished at a profit. The average yield of crops without top-dressing ranged from 9.3 to 15.4 bushels of grain, and the increase from the application of 100 pounds

of nitrate of soda ranged from 21 to 37 per cent. for grain, and from 33.5 to 37 for straw, or an average increase of 28.5 per cent for grain and 35.7 for straw. The yield obtained without top-dressing is not so large as in the case of the wheat, nor is the increase proportionately as large, due undoubtedly to the facts that the rye is usually grown on poorer land than wheat, and that only 100 pounds were used, though this small amount was recommended because of the relatively lower price of grain. Applying this percentage increase, however, to the average yields, as shown by the States mentioned, namely, fifteen bushels of rye, and 1,800 pounds of straw per acre, we have a gain of 4.28 bushels of grain and 603 pounds of straw. At sixty cents per bushel for the grain, and $12 per ton for the straw, the gain is $6.18, or a net profit from the use of nitrate of soda of $3.93 per acre, a very handsome return for the investment. The suggestions as to the amount and time to apply are practically the same as for the wheat and hay, though, owing to the fact that the straw is relatively more valuable than the grain, the larger applications may be made for the rye than for wheat, as an abnormal increase in the proportion of straw would not result in lowering the total value of the crop.

Experiments with Forage Crops.

At this Station during the years 1899 to 1902 seven experiments were conducted with nitrate as a top-dressing on forage crops, the nitrate being used in addition to the manures and fertilizers generally used, and the following tabulations show the yield and gain per acre obtained. It will be observed that in all cases a very marked increase due to the application of nitrate occurred, ranging from 34.1 per cent. for corn to 96.6 per cent. for barley—a profitable return from the use of the nitrate on all crops except the barley, which, owing to unfavorable weather conditions, did not make a large yield. Applying this percentage increase to what has been shown to be average yields of these crops without nitrate, we have the following table, which shows the gain per acre and the value of the increase on all crops at an assumed value of $3 per ton:

Yield of Forage Crops Per Acre.

	Number of experiments.	FERTILIZER. Nothing.	FERTILIZER. Nitrate of soda.	Increased yield.	Percentage, gain.	Average yield.	Increased yield.	Value of increased yield at $3 per ton.
		lbs.	lbs	lbs.		lbs.	lbs.	
Rye..	1	9,520	13,100	3,580	37.6	10,000	3,760	$5 64
Wheat	1	9,280	15,000	5,720	61.6	10,000	6,160	9 24
Barnyard Millet.	2	14,355	21,540	7,185	50.0	14,000	7,000	10 50
Corn	1	20,400	26,800	6,400	31.4	20,000	6,280	9 42
Oats and Peas	1	6,250	9,530	3,280	52.5	10,000	5,250	7 88
Barley..	1	2,400	4,720	2,320	96.6	8,000	7,728	11 59

It will be observed that the value of the increased crop ranges from $5.64 to $11.59 per acre—a profitable increase in every case, as the average cost of the nitrate did not exceed $3.60. This profit does not take into consideration the fact that the average increase for all the crops was over 50 per cent., thus reducing, in this proportion, the area required for the production of a definite amount of food—a point of vital importance in the matter of growing forage for soiling purposes. In other words, it is shown that, not only is there a profitable gain, but that with these crops the application of nitrate of soda made it possible to double the number of cattle or the number of cows that could be kept on a definite area.

Methods of Application.

In the case of the wheat and rye the application was made when the plants were well started in the spring. In the case of the spring or summer-seeded crops the applications were made after the plants were well started and root systems well established and ready for the rapid absorption of food. In raising forage crops the best results, in fact, satisfactory results, can only be obtained when grown under the intensive system. The soil must be well prepared and an abundance

of all the elements of plant-food supplied. Hence, the application of nitrate may be greater than is usually recommended for grain crops under the extensive system.

Although there are many valuable suggestions offered by the experiments, at least two are of fundamental importance, and cannot be too strongly urged upon the attention of farmers:

1. That the constituents nitrogen, phosphoric acid and potash, as found in commercial supplies furnishing these elements, do serve as plant-food, nourishing the plant in the same manner as those in home manures, and should, therefore, be liberally used, in order to guarantee maximum crops.

2. Of these constituent elements nitrogen is of especial importance, because it is the one element which, in its natural state, must be changed in form before it can be used by the plants. Hence, its application in an immediately-available form is especially advantageous for quick-growing vegetable crops, whose marketable quality is measured by rapid and continuous growth, and for those field crops which make their greatest development in spring, before the conditions are favorable for the change of the nitrogen in the soil into forms usable by plants.

REPORT OF THE ASSISTANT IN SOIL CHEMISTRY AND BACTERIOLOGY.

SOIL CHEMISTRY AND BACTERIOLOGY.

EXPERIMENTS ON THE TRANSFORMATION AND FIXATION OF NITROGEN BY BACTERIA.

The Object of the Experiments and the Methods Employed.*

The purpose of these investigations was to determine the behavior of bacterial mixtures, as they are found in fresh soils, in nitrogen-rich and in nitrogen-poor solutions; to determine what losses of nitrogen may occur in one case, and what gains of nitrogen in the other; to search for nitrogen-fixing bacteria; to isolate them in pure culture, and to study their physiological and morphological characteristics. For the quantitative determination of nitrogen, the Kjeldahl method and the Kjeldahl modified were used.[1] Where small quantities of nitrates or nitrites were to be determined, the phenol-sulphonic acid and the naphtylamine and sulphanilic acid methods, respectively, were employed.[2] Ammonia was determined by distillation with magnesia and subsequent titration against standard solutions, and diphenylamine in sulphuric acid was used for qualitative tests for nitrate. The standard solutions employed were about one-fifth normal, drawn from fine burettes, which allowed careful reading and very satisfactory results from the standpoint of accuracy.

Changes in Nitrogen-Rich and in Nitrogen-Poor Solutions.

When a sterile nutrient solution is inoculated with a small quantity of fresh soil, the resulting growth may cause a loss or a gain of nitrogen, or it may leave the original amount unchanged. The processes which take place here are determined by the nature of the solution,

*A part of the material presented here was also presented in a thesis for the degree of Ph.D., Cornell University, June, 1903.

[1] Rev. Ed. Bull, 46 U. S. Dept. of Agr., Div. of Chemistry.

[2] See J. G. Lipman, Master's Thesis, Cornell University, 1900.

by the character of the soil used for inoculation, and by the conditions under which the bacterial growth takes place. When a solution rich in soluble organic nitrogen is employed, as, for instance, meat-extract bouillon, a rapid development of many species takes place, a pellicle is usually developed on the surface of the solution which is now turbid, a more or less voluminous sediment appears, and the whole almost always acquires an offensive odor. Under these conditions of growth the soluble nitrogen compounds suffer very considerable changes. A part of the soluble organic nitrogen is transformed into the insoluble organic form, the greater part is broken down and simplified, involving the production of amido-compounds, of ammonia and probably of elementary nitrogen, but in all cases the solution contains less nitrogen at the end of the experiment than it does at the beginning.

When, on the other hand, a nutrient solution is employed which contains mere traces of combined nitrogen, but contains the proper proportions of mineral salts and of some suitable organic non-nitrogenous compound, the resulting growth will lead to an increase of combined nitrogen. Thus we see that the same inoculation material yields different results in the two solutions. Naturally, the question arises whether the same organisms develop in the two solutions, for, since the same inoculation material was employed, it must be assumed that the latter contained the same organisms at the start. As a matter of fact, the bacterial growth in meat-extract bouillon is different in quality and quantity from that in a solution of mannite containing, also, the proper mineral salts, when the same soil is used for inoculation. None the less, some organisms may be represented in the two solutions, though to an unequal extent. An explanation, then, of the function of these bacteria and of other soil organisms in artificial solutions may make clearer their functions in the soil. The problem in the latter case is complicated and difficult because of the many factors involved, and the analytical method in the study of this subject must be employed in order to reduce it to simpler terms. For this purpose, the study of single species in pure culture is of great advantage. In this manner the characteristic behavior of the different organisms may be ascertained with greater exactness. The following experiment, carried out with single species and with a mixture of soil bacteria, may serve to show the relation of the inoculation material to the soluble organic nitrogen and its transformation. The meat-extract bouillon used in this experiment was prepared ac-

cording to the direction given by Chester,[1] and was made faintly alkaline to phenolphthalein. Fifty cubic centimeter portions of sterile bouillon were carefully pipetted into Kjeldahl flasks, the latter were plugged with cotton and sterilized in the autoclave. On cooling, the bouillon was inoculated according to the following scheme:

Flask 1. Sterile.
" 2. "
" 3. "

" 4. B. pyocyaneus.
" 5. "
" 6. "

" 7. From pasteurized Freehold soil.
" 8. " " " "
" 9. " " " "

" 10. From non-pasteurized Freehold soil.
" 11. " " " "
" 12. " " " "

" 13. From pasteurized Vineland soil.
" 14. " " " "
" 15. " " " "

" 16. From non-pasteurized Vineland soil.
" 17. " " " "
" 18. " " " "

Flasks 4, 5 and 6 were inoculated with a pure culture of B. pyocyaneus; flasks 7, 8, 9, 13, 14 and 15 with one loopful each of a raw culture, which was obtained as follows: Fifteen to twenty grams of fresh soil, obtained from Freehold and Vineland, N. J., were each placed in a large test tube, the latter plugged with cotton and kept in hot water at a temperature of 85° for five minutes. The soil thus pasteurized was inoculated into a mannite solution containing the necessary quantity of the mineral salts and but traces of combined nitrogen. This latter solution, kept in the incubator at 28° C., soon showed a strong turbidity and a surface growth. At the end of three days this solution was used for inoculation. A similar procedure was followed with flasks 10, 11, 12, 16, 17 and 18, except that in this case the soil was not pasteurized. The inoculated flasks were placed in the incubator at 28° C., and observations were made from time

[1] Manual of Determinative Bacteriology, p. 28.

to time as to changes in appearance. The contents of one flask in each series were analyzed at the end of six days, of the second flask at the end of twelve days, and of the third flask at the end of eighteen days. At the end of six days the contents of flasks 1, 4, 7, 10, 13 and 16 appeared as follows:

1. Clear.
4. Turbid, deposit, and bluish film on surface.
7. " " " white pellicle on surface.
10. " heavy deposit, and a white pellicle on surface.
13. Cloudy, deposit.
16. Turbid, white pellicle, deposit.

The plugs were then withdrawn from the flasks, 20 cc. of sulphuric acid and one drop of metallic mercury added, and the contents digested until clear. The rest of the analytical work was carried out in the customary manner, and the following results were obtained:

At the End of Six Days.

	Standard HCl. taken.	Standard NH_4OH.	Titrated back.	Or in solution in Terms of NH_4OH.	Weight of Nitrogen.
1..........	20 cc.	=53.50 cc.	15.35 cc.	38.15 cc. or	114.48 mg.
4..........	20 "	=53.50 "	15.60 "	37.90 " "	113.74 "
7..........	20 "	=53.50 "	16.70 "	36.80 " "	110.44 "
10..........	20 "	=53.50 "	17.05 "	36.45 " "	109.39 "
13..........	20 "	=53.50 "	18.20 "	35.30 " "	105.93 "
16..........	20 "	=53.50 "	20.30 "	33.20 " "	99.63 "

In this case 1 cc. of the standard NH_4OH was equal to .003001 gr. of nitrogen.

At the End of Twelve Days.

	Standard HCl. taken.	Standard NH_4OH.	Titrated back.	Or in solution in Terms of NH_4OH.	Weight of Nitrogen.
2..........	20 cc.	=53.20 cc.	15.30 cc.	38.20 cc. or	114.63 mg.
5..........	20 "	=53.50 "	19.10 "	34.40 " "	103.23 "
8..........	20 "	=53.50 "	19.55 "	33.95 " "	101.88 "
11..........	10 "	=26.75 "	4.40 "	22.35 " "	70.07 "
14..........	20 "	=53.50 "	19.55 "	33.95 " "	101.88 "
17..........	10 "	=26.75 "	5.30 "	21.45 " "	64.37 "

Also in this case 1 cc. of the standard NH_4OH was equal to .003001 gr. of nitrogen.

At the End of Eighteen Days.

	Standard HCl. taken.	Standard NH_4OH.	Titrated back.	Or in solution in Terms of NH_4OH.	Weight of Nitrogen.
3..........	20 cc.	=54.10 cc.	15.60 cc.	38.50 cc. or	114.11 mg.
6..........	20 "	=54.10 "	21.75 "	32.35 " "	95.88 "
9..........	20 "	=54.10 "	23.55 "	30.55 " "	90.55 "
12..........	10 "	=27.05 "	7.80 "	19.25 " "	57.06 "
15..........	20 "	=54.10 "	18.65 "	35.45 " "	105.07 "
18..........	10 "	=27.05 "	8.20 "	18.85 " "	55.87 "

In this case 1 cc. of the standard NH_4OH was equal to .002964 gr. of nitrogen.

It is quite evident that there was a loss of nitrogen in every instance, and that these losses tended to increase gradually, as may be seen at a glance from the following tabulation:

Nitrogen in Solution.

	In six days.	In twelve days.	In eighteen days.
Sterile bouillon..................	114.48 mg.	114.63 mg.	114.11 mg.
B. pyocyaneus..................	113.74 "	103.23 "	95.88 "
Pasteur. Freehold soil...........	110.44 "	101.88 "	90.55 "
Non-pasteur. Freehold soil.......	109.39 "	70.07 "	57.06 "
Pasteur. Vineland soil...........	105.94 "	101.88 "	105.07 "
Non-pasteur. Vineland soil.......	99.63 "	64.37 "	55.87 "

The amount of nitrogen found in the sterile bouillon at the end of twelve days is somewhat higher than that found at the end of the sixth and eighteenth days, respectively, and may be explained by the concentration of the bouillon whereby small differences in pipetting off may lead to greater discrepancies in the final results. Nevertheless, the agreement may be considered very satisfactory. Taking the average of the three, the amount of nitrogen originally present in the bouillon was 114.40 mg. This amount was diminished in every inoculated culture, although the losses were not evenly distributed through the three equal periods.

Losses of Nitrogen from the Several Cultures.

	In the First 6 Days.	In the Second 6 Days.	In the Third 6 Days.	Total Loss in 18 Days.
B. pyocyaneus......	.66 mg. = .6%	10.51 mg. = 9.2%	7.35 mg. = 6.4%	18.52 mg. =16.2%
Past. Freehold......	3.96 mg. = 3.4%	8.56 mg. = 7.5%	11.33 mg. = 9.9%	23.85 mg. =20.9%
Non-past...........	5.91 mg. = 5.2%	39.32 mg. =34.4%	13.01 mg. = 11.4%	58.24 mg. =50.9%
Past Vineland......	8.47 mg. = 7.4%	4.05 mg. = 3.5%	+ 3.19 mg. = + 2.8%	9.33 mg. = 8.1%
Non-past	14.77 mg. =12.9%	35.26 mg. =30.8%	8.50 mg. = 7.4%	58.53 mg. =51.1%

It will be seen that the losses are in some cases very considerable, and greatest where the non-pasteurized material was employed. The bouillon inoculated from the non-pasteurized Freehold and Vineland soil caused in eighteen days a loss of 50.9 per cent. and 51.1 per cent., respectively. In other words, more than one-half of the initial amount of nitrogen was lost. The losses were greatest in most cases during the second period, and least in the first period. It will also be noticed that the pure culture of B. pyocyaneus caused smaller losses than even the pasteurized Freehold soil. The differences between the losses caused by the pasteurized soils, on the one hand, and by the non-pasteurized soils on the other, are very striking. The pasteurization undoubtedly destroyed most or all of the non-spore-forming bacteria, and those that were left behind could not produce as rapid and as wide-reaching a decomposition of the nitrogenous organic matter. From the analytical data, it also appears that the pasteurization was more destructive to the bacteria in the Freehold soil. Microscopical examination also showed that the latter soil is much richer in spore-forming bacilli than is the Vineland soil. This is undoubtedly due to the very decided differences in the character of the two soils. The Freehold soil is a very compact, fine-grained soil, rich in organic matter; the Vineland soil is sandy, porous and well drained. The former contains[1] .125 per cent. of nitrogen, and shows a loss on ignition of 7.23 per cent.; the latter contains only .055 per cent. of nitrogen, and shows a loss on ignition of 3.30 per cent. Apparently the less perfectly aerated Freehold soil contains a greater variety of spore-bearing ærobic and anærobic bacteria. The loss from inoculation with the Freehold pasteurized soil was 20.9 per cent. in eighteen days, and only 8.1 per cent. from the Vineland pasteurized soil in the same period. The discrepancy should be noted in the latter case, as shown by the analytical work. It will be noticed that there was a loss in six days of 8.47 mg., and an additional loss in the next six days of 4.05 mg. In the third period, however, there is a distinct increase from 101.88 mg. to 105.07 mg. These results may be explained in two ways. Either there was a slight fixation of nitrogen in the solution or there was an error in the analytical work. The first assumption, while not excluded, is hardly probable, because of the high content of nitrogen in the solution, and it must be assumed, therefore, that the determination of 101.88 mg. was too low, because of some error that had crept in and was not noticed. This is the more plausi-

[1] J. G. Lipman, N. J. Station Rep., 1902, p. 240.

ble, since the amount of nitrogen found at the end of eighteen days was slightly less than that found at the end of six days. As will be shown in another place, there are bacteria which can produce an extensive growth in bouillon or any other nitrogen-rich solution, and an almost complete transformation of the soluble nitrogen into insoluble organic nitrogen without causing at the same time a loss of nitrogen from the solution, and it is very probable that the vigorous growth produced by the Vineland pasteurized soil was largely due to such bacteria. The non-pasteurized soils also showed marked differences. Thus in the inoculations from the Freehold soil, the loss in the first six days was 5.2 per cent., as against 12.9 per cent. in the inoculations from the Vineland soil. In the second and third periods the losses due to the former are greater and the total losses in eighteen days are practically the same in the two cases. The losses caused by B. pyocyaneus were distributed mostly between the second and third periods.

The losses of nitrogen in these experiments are undoubtedly due, to a great extent, to the formation and volatilization of ammonia. There is much experimental evidence to show that the formation of ammonia from nitrogenous organic compounds is characteristic of most bacteria. Marchal,[1] for instance, found that, out of thirty-one organisms tested by him, seventeen produced ammonia from egg albumen, and most of the others gave a slight, but distinct, reaction for ammonia. B. mycoides transformed, in twenty days, 46 per cent. of the organic nitrogen into ammonia, which was the maximum in the experiment; and the minimum amount, and namely, 16 per cent., was transformed by B. fluorescens liquefaciens. Eight cultures of B. mycoides, derived from different sources, showed a varying ammonia-producing power. Marchal also found that the transformation of organic nitrogen into ammonia is the more complete the less there is of the former in solutions. A number of proteids tried showed marked differences as to the ammonia produced from them in a given time (twenty days in this case), varying from 4.5 per cent. in gluten to 22 per cent. in peptone.

Sewerin[2] found the production of ammonia characteristic of a number of bacteria, but to an unequal extent. Some of them produced ammonia during the early part of the experiment, others during the latter part of the experiment. Chester[3] also tested a number of soil

[1] Agricultural Science, VIII., 1894, p. 574.
[2] Centr. f. Bact. u. Par. II., Vol. I. (1895), p. 167.
[3] Del. St. Rep., 1899, p. 79.

bacteria for their ammonia-producing power, and found that, with one exception (microspira tenuis), all produced ammonia. The greatest amount was produced by B. subtilis, which yielded per 100 cc. of culture, that contained originally 216 mg. of nitrogen, calculated as NH_4, 6.46 mg., 18.35 mg. and 46.20 mg., respectively, for seven, fourteen and thirty days. B. pulvinatus yielded 0 mg., 5.78 mg. and 18.30 mg., respectively, in seven, fourteen and thirty days; B. fermentationis, .30 mg., 8.50 mg. and 27.90 mg. in seven, fourteen and thirty days, respectively.

Gerlach and Vogel[1] isolated from soil, and from manure, a number of bacteria which are capable of transforming inorganic nitrogen salts into insoluble organic nitrogen, but when *organic* nitrogen was used its transformation into proteid was accompanied by loss of nitrogen. When nitrate was used as the only source of nitrogen, it was reduced to nitrite, but ammonia could not be detected. Finally, neither nitrate nor nitrite could be found, and a determination of total nitrogen showed no loss. A culture of the same solution was kept at 25° for fourteen days, filtered through a clay filter, and the nitrogen in the filtrate determined. Only 1.4 mg. were found out of the 100 mg. originally present. Similar results were obtained when, instead of glucose, glycerine, straw, etc., were used as a source of carbon. When ammonium nitrate or ammonium sulphate were used, instead of the nitrate, the results were similar, except that the formation of proteid was more gradual. Proteid was also formed with urea as the nitrogen source. The growth was, however, slow, and was accompanied by loss of nitrogen, due, probably, to the volatilization of ammonia. When these bacteria were inoculated together with B. ureæ, in a bouillon containing 2 per cent. of urea, it was found that the two caused a loss, in eleven days, of 13.2 per cent., and in nineteen days of 29 per cent. B. ureæ alone caused, in eleven days, a loss of 13.0 per cent. and in nineteen days of 36.9 per cent., while the proteid-forming bacteria (the name applied to the organisms isolated by them) alone caused, in eleven days, a loss of 0 per cent. and in nineteen days of 9 per cent. In forty-two days the two together caused a loss of 57.8 per cent., which the authors ascribe to the volatilization of ammonia. These experiments, taken together with Berthelot's[2] observations on the volatilization of ammonia from arable soils, make it quite clear that the

[1] Centr. f. Bact. u. Par. II., Vol. VII. (1901), p. 609.

[2] Chimie Vegetale et Agricole, p. 160.

activities of bacteria lead to very considerable losses of nitrogen in the form of ammonia. At the same time, extensive losses of nitrogen may occur through the setting free of elementary nitrogen, also by bacteria. This may take place either in the presence or absence of nitrates, and a discussion of this question, together with references to the literature of the subject, may be found in the New Jersey State Experiment Station Report for 1902.[1]

An instance may be given, however, to show the different behavior of two bacteria in nitrate bouillon, directly bearing on the point in question. A number of bacteria were inoculated into 10 cc. portions of nitrate bouillon, containing 23.88 mg. of total nitrogen. At the end of twenty-eight days the cultures were analyzed; the following analytical data were obtained:

	Insoluble Organic Nitrogen.	Ammonia Nitrogen.	Nitrate Nitrogen.	Total Nitrogen.
Sterile	....	....	1.020 mg.	23.88 mg.
B. subtilis	0.687 mg.	4.662 mg.	lost "	18.93 "
"	0.542 "	4.986 "	1.030 "	19.26 "
B. pyocyaneus	1.518 "	3.684 "	0.150 "	15.96 "
"	1.012 "	4.011 "	0.135 "	15.95 "

It will be seen that B. subtilis caused here a considerable loss of nitrogen. Since, however, the nitrate was left unattacked, it must be assumed that the loss was due to the decomposition of the organic nitrogen. Almost 5 mg. of ammonia were formed here, and more than .5 mg. of insoluble organic nitrogen. In the case of B. pyocyaneus, on the other hand, the greater part of the nitrate was destroyed with the evolution of free nitrogen. A much larger loss was caused here than in the case of B. subtilis, which is not accounted for by the nitrates alone, and it must be assumed that the nitrate stimulated the growth of B. pyocyaneus and led to a more extensive decomposition of the organic matter. The amount of insoluble organic nitrogen produced here is more than twice the amount produced by B. subtilis, while the amount of ammonia produced here is less than that produced by B. subtilis.

B. pyocyaneus causes a greater loss of nitrogen from solutions as the depth of the liquid is decreased, and the surface exposed to the air is increased. The better aeration thus produced is evidently the cause of the greater loss, although it has not been determined whether the latter is due to the increased volatilization of ammonia as such

[1] J. G. Lipman, N. J. St. Rep., 1902, p. 183.

or to the increased oxidation of the ammonia and the resulting liberation of elementary nitrogen. The following experiment illustrates the effect of aeration on cultures of B. pyocyaneus. Twenty-five cubic centimeter portions of meat-extract bouillon were pipetted into dishes of varying diameter, according to the following scheme:

			Internal diameter of dish.
1	25 cc. bouillon		
2	25 " "	+1 gr. $CaCO_3$	5.00 cm.
3	25 " "		
4	25 " "	+1 gr. $CoCO_2$	6.75 cm.
5	25 " "		
6	25 " "	+1 gr. $CaCO_2$	9.00 cm.
7	25 " "		
8	25 " "	+1 gr. $CaCO_3$	Small flasks.

Nos. 2, 4, 6 and 8 each had one gram of calcium carbonate added to the contents of the dish (or flask), 7 and 8 were kept sterile. On inoculation with B. pyocyaneus, the dishes were placed in the incubator and kept there at 28° C. for ten days. At the end of that time the cultures were placed in the autoclave, sterilized, transferred to Kjeldahl flasks, and the nitrogen determinations made according to the Kjeldahl method. The results obtained were as follows:

	Nitrogen found.	Diameter of dish.
1	51.06 mg.	5.00 cm.
2	50.17 "	
3	lost. "	6.75 "
4	41.94 "	
5	lost "	9.00 "
6	40.76 "	
7	56.80 "	
8	57.24 "	

Unfortunately 3 and 5 were accidentally upset in the digestion, and the calculations must be based on the single determinations. These are sufficient, however, to show the influence of the depth of the culture medium on the loss of nitrogen. Tabulating the losses in the several cultures we find the following:

	Loss of nitrogen.
1	5.96 mg. or 10.4 %
2	6.85 " " 12.0 "
4	15.08 " " 26.4 "
6	16.26 " " 28.5 "

These results show that there was a decidedly increased loss of nitrogen from the bouillon as the diameter of the dish increased.

Fixation of Nitrogen by Bacterial Mixtures in Nitrogen-Poor Solutions.

The first attempts at the isolation of nitrogen-fixing bacteria were made with two solutions of somewhat different composition. These were called solution A and solution B, respectively, and were made up as follows:

Solution A.	Solution B.
1,000 cc. distilled water.	1,000 cc. tap water.
0.5 grams K_2HPO_4.	0.2 grams K_2HPO_4.
0.5 " NaCl.	0.2 " Mg SO_4.
20.0 " glucose.	0.2 " NaCl.
A drop of Fe_2Cl_6.	20.0 " glucose.

When these solutions were used, there was usually added .5 gr. of $CaCO_3$ to the contents of each culture flask. Portions of these solutions were placed in Erlenmeyer flasks and each was inoculated with 20 gr. of greenhouse soil, and one flask of each was also inoculated with 20 gr. of red shale that, so far as is known, had never been under cultivation.

In twenty-four hours there was evident fermentation in the solutions inoculated with greenhouse soil, with the formation of a thin film on the surface. In the solutions inoculated with the red shale the growth was still slight. A microscopical examination of the former at this time showed the presence of different bacteria, and prominent among them large rods and clostridia. The great majority of the organisms in solutions were small bacteria, which stained unevenly. In forty-eight hours the large rods were fewer, and a large number of diplococci appeared in the solution. Several days later a heavy membrane was found on the surface and was found to be contaminated with molds. Microscopical examinations showed the membrane to consist largely of diplococci, although chains of four or more organisms were not rare. These stained readily with carbol fuchsin, and also with Loeffler's methylene blue, and were easily decolorized by alcohol. Besides the cocci, there were present in the membrane numerous rod-shaped organisms, and among them filaments appearing like a sheath, in which chains of short rods were enclosed. In the solutions inoculated with the red shale there was also a membrane at the surface. This membrane consisted largely of rods, and also of a considerable number of cocci united in sarcina-like masses and ap-

pearing to differ from the diplococci formed in the solution which were inoculated with the greenhouse soil. In solutions A, inoculated with the latter, there was found in three weeks an abundant growth consisting of actively motile cocci and diplococci, with granular bodies, which collected in the hanging drop, near the edge of the drop. There were also present numerous bacilli, some of them rather long and bent.

These raw cultures were used for inoculation into various nitrogen-free media in order to see whether they were capable of fixing appreciable quantities of nitrogen.

Series I.

The solution used in this series contained per liter—

2.0 grams $MgSo$.
2.0 " K_2HPO_4.
0.2 " $CaCl_2$.
2.0 " glucose.
5.0 " citric acid.
2.0 drops of Fe_2Cl_6.

The solution was made faintly alkaline to phenolphthaleine, and distributed in 100 cc. portions with small Erlenmeyer flasks. Very slight quantities of nitrate were also added in each flask, in order to promote the initial growth of the bacteria. After sterilization and cooling these were inoculated according to the following scheme:

1. Nutrient solution +0.5 mg. NH_4NO_3....Sterile.
2. " " " " $Na\ NO_3$....
3. " " " " NH_4NO_3....Mixture from greenhouse soil.
4. " " " " $Na\ NO_3$....
5. " " " " NH_4NO_3....Mixture from red shale.
6. " " " " $Na\ NO_3$....

In twenty-four hours 1 and 2 were clear, 3 and 4 were slightly turbid, 5 and 6 were clear. In three days 1 and 2 were clear, while the others all showed growth. In four weeks the cultures were sterilized, filtered, and the residue on the filter, as well as the filtrate, were both analyzed according to the Kjeldahl method. It was found that small, but very appreciable, quantities of nitrogen were fixed in the inoculated solutions. In order to show that the method is

absolutely reliable for such small quantities of nitrogen (as had already been found in the fixation experiments with B. pyocyaneus), the amounts of the standard solutions used here are also given.

Blank titrations showed 10 cc. HCl = 27.35 cc. NH_4OH, calculated according to the value of 1 cc. of the standard HCl, 1 cc. NH_4OH = .002827 gr. N.

Ten cc. portions of the standard HCl were drawn, diluted with distilled water, and placed under the distilling apparatus. After distillation the distillate received, in each case, about 2 cc. of cochineal in alcohol and standard NH_4OH was added until the neutral point was reached. Following are the results:

Insoluble Nitrogen.

	Amt. of St. HCl. cc.	In terms of St. NH_4OH. cc.	NH_4OH titrated back. cc	NH_4OH equivalent in sample. cc.	Nitrogen Fixed. mg.
1..................	10 cc.	=27.35	27.05	0.30	....
2..................	10 "	=27.35	27.10	0.25	....
3..................	10 "	=27.35	26.70	0.65	1.27
4..................	10 "	=27.35	26.80	0.55	0.99
5..................	10 "	=27.35	26.90	0.45	0.56
6..................	10 "	=27.35	26.90	0.45	0.56

Soluble Nitrogen.

1..................	10 cc.	=27.35	27.05	0.30	....
2..................	10 "	=27.35	27.05	0.30	....
3..................	10 "	=27.35	27.00	0.35	....
4..................	10 "	=27.35	27.05	0.30	....
5..................	10 "	=27.35	27.05	0.30	....
6..................	10 "	=27.35	27.10	0.25	....

These results show that the bacterial mixture from the greenhouse soil fixed a greater amount of nitrogen than that from the red shale; that the nitrogen fixed was in the insoluble organic form, and that the minute quantity of ammonium nitrate made possible a better growth than the same amount of sodium nitrate. As will be seen, the filtrate contained no nitrogen, with the exception, possibly, of 3, where traces of nitrogen seemed to be present in the filtrate. However, the amount is not much beyond the limit of error, and is disregarded here.

Greater amounts of nitrogen were fixed by mixtures of soil bacteria in solutions composed as follows:

1,000	cc.	tap water.
0.5	grams	K_2HPO_4.
20.0	"	mannite.

A similar solution was also prepared, containing, instead of mannite, 20 gr. of glucose per liter.

Series II.

One hundred cc. portions of the mannite solution were distributed in small Erlenmeyer flasks, 5 gr. of soil and 1 gr. of $CaCO_3$ added to each, and the flasks and contents sterilized in the autoclave. On cooling they were inoculated with mixtures of soil bacteria, according to the following scheme:

1. Sterile
2. Mixture from greenhouse soil.
3. " " " "
4. " " " "
5. " " " "

In two days there was evident growth in all, except 1. Microscopical examination at this time showed a predominating number of bacilli. In four days there was strong growth and fermentation in all of the inoculated flasks. At the end of two weeks the cultures were analyzed, and the following amounts of nitrogen found:

	Amount found. mg	Amount fixed. mg.
1	2.10	....
2	5.91	3.81
3	6.36	4.26
4	6.50	4.40
5	6.35	4.25

The amount of nitrogen found in the inoculated flask represents that contained in the .5 gr. of soil, and in the other reagents at the beginning of the experiment. The amount found in each of the other flasks, less 2.10 mg., represents the amount of nitrogen fixed in each case. It appears, therefore, that there were fixed in the highest case 4.40 mg. of nitrogen for the two grams of mannite originally present in the solution, or 2.20 mg. for each gram of mannite used.

Series III.

In this series a number of Erlenmeyer flasks, containing 100 cc. portions of the nitrogen-free glucose solution were inoculated with the same mixtures of soil bacteria that were used for the inoculation of Series A of the bouillon cultures. This series shows admirably that the same inoculation material produces widely different results, according to the nature of the solution. The arrangement of this experiment was as follows:

1. Sterile.
2. Sterile.
3. B. pyocyaneus.
4. Pasteurized soil, Freehold.
5. Non-pasteurized soil, Freehold.
6. Pasteurized soil, Vineland.
7. Non-pasteurized soil, Vineland.

In twenty-four hours after inoculation, 1 and 2 were clear, 3, 4 and 5 were cloudy, 6 was clear and 7 was turbid. In six days there was more or less pronounced growth in 3, 4, 5 and 7, while 1, 2 and 6 remained clear. A microscopical examination in ten days showed numerous spores and long rods in 4; numerous rods, a few clostridia, many small bacilli and very few large cocci in 5; very few rod-shaped organisms in 6; large rods and diplococci, small bacilli and long, slender rods in 7. In the last culture growth was more abundant than in any of the others, while in 6 it was scarcely perceptible microscopically.

At the end of fourteen days the several flasks were sterilized and treated according to the Kjeldahl method, with the following results:

1. 0 mg. of nitrogen.
2. 0 "
3. Traces
4. 2.40 mg.
5. 2.85 mg.
6. Traces.
7. 2.70 mg.

There was evidently a gain of nitrogen in most of the inoculated solutions. In 3, which was inoculated with B. pyocyaneus, there was evident growth, and the examination in hanging drop showed the presence of living bacilli; nevertheless, the gain was so slight (.15

mg.) as to be within the limit of experimental error. The same also applies to 6, which was inoculated from the pasteurized Vineland soil. This shows that the pasteurization, in the case of the Vineland soil, was more effective than in the case of the Freehold soil; or, in other words, the latter contained more spore-bearing organisms than the former. At any rate, the pasteurization of the Vineland soil practically destroyed in it all of the organisms capable of developing in nitrogen-free solutions, and of fixing atmospheric nitrogen. It also seems that the spore-bearing organisms in the pasteurized Freehold soil were capable of fixing very considerable quantities of free nitrogen, almost as much as was fixed by the bacterial mixture in the non-pasteurized soil. Taken together with the fact that the latter contained but few azotobacter bacteria (the large diplococci), it would appear that the nitrogen-fixing agents in the Freehold soil are the spore-bearing bacteria, probably butyric ferments, while in the Vineland soil the nitrogen-fixing agents are the large ærobic organisms of the Azotobacter group.

Series IV.

In this series 100 cc. of the mannite solution, 1 gr. of soil and 1 gr. of $CaCO_3$ were placed in each of seven Erlenmeyer flasks. These were plugged with cotton, sterilized in autoclave, cooled and inoculated as follows:

1. Sterile.
2. "
3. Raw culture of Azotobacter (mixture of Azotobacter and small bacilli).
4. From pasteurized soil, Vineland.
5. From non-pasteurized soil, Vineland.
6. From pasteurized soil, Freehold.
7. From non-pasteurized soil, Freehold.

In four days there was evident growth in all of the flasks, except 1 and 2. The solution in 3 was cloudy, with signs of a surface film; in 4 it was cloudy, with beginning fermentation; in 5 it was turbid and with a film on surface; in 6 it was cloudy, with signs of fermentation, and in 7 it was but slightly cloudy. In twenty days there was turbidity in all of the inoculated flasks, with the heavy characteristic membrane in 3 and partial membrane in 5 and 7. In 4 and 6 there had evidently been a fermentation of the

mannite. The flasks were then placed in the autoclave, sterilized, cooled and treated according to the Kjeldahl method, with the following results:

	Amount found.	Amount fixed.
1..................	1.90 mg. of nitrogen	....
2..................	Lost.	
3..................	4.72 " " "	2.82 mg.
4..................	3.40 " " "	1.50 "
5..................	10.34 " " "	8.44 "
6..................	4.43 " " "	2.53 "
7..................	4.13 " " "	2.23 "

The contents of flask 2 foamed over during digestion, and the determination was lost. It should be noted here that considerable trouble was occasioned by the tendency of the glucose and mannite media to foam during digestion, and, in spite of great watchfulness, many determinations were thus lost in the course of these investigations. In this particular experiment, however, the duplicate sterile sample 1 was sufficient to show the amount of nitrogen contained in the soil and in the reagents, for the same amounts of nitrogen were found in the sterile samples in the other experiments, where the same soil was added to promote the initial growth of the bacteria. The amounts of nitrogen fixed were obtained by subtracting the amount found in the sterile flasks from the amounts of nitrogen found in the others.

It will be seen that, in this case, the least amount of nitrogen was fixed by the bacterial mixture from the pasteurized Vineland soil; that the bacterial mixture from the Freehold pasteurized soil fixed a slightly greater amount of nitrogen than did the bacterial mixture from the non-pasteurized Freehold soil, and that the bacteria in the non-pasteurized Vineland soil fixed, by far, the greatest quantity of nitrogen in the entire series. These results confirm those obtained in Series III., and show, again, that, in the Freehold soil, the fixation is largely due to spore-bearing bacilli, while in the Vineland soil the fixation is largely due to non-spore-bearing bacteria of the Azotobacter group. The latter can use the organic substance to greater advantage, undoubtedly, for the work of Winogradsky, Beijerinck and van Delden, and of Vogel and Gerlach, shows that Azotobacter chroococcum can fix a greater amount of nitrogen per gram of organic substance than Clostridium Pasteurianum. There is one point here, however, which needs clearing up. According to

Beijerinck,[1] the butyric ferment attacks mannite only with great difficulty; and the question arises here whether the fixation by the organisms from the Freehold soil was due to this group of organisms. Since, however, other bacteria were present, and since there was evident fermentation of the mannite during growth, it is not impossible that the nitrogen-fixing bacteria in this case belonged to the group of butyric ferments.

Comparing the amounts of nitrogen fixed in Series III., where glucose was used, with the amounts of nitrogen fixed in Series IV., where mannite was the only source of organic carbon, we find the following:

Nitrogen fixed in—

	Series III.	Series IV.
By bacteria from—		
Freehold, pasteurized	2.40 mg.	2.53 mg.
" non-pasteurized	2.85 "	2.33 "
Vineland, pasteurized	Traces.	1.50 "
" non-pasteurized	2.70	8.44 "

These tabulations show that there was on the average more nitrogen fixed in glucose than there was in mannite, by the bacteria from the Freehold soil. It is quite different with the mixture of bacteria from the Vineland soil. These fixed practically no nitrogen at all in glucose when pasteurized material was employed, and somewhat less than the corresponding bacterial mixture from the Freehold soil when non-pasteurized material was used. In mannite, on the other hand, there was a fixation of 1.50 mg. with the pasteurized material, and of 8.44 mg. with the non-pasteurized material, a fixiation in the later case of 4.22 mg. of nitrogen per gram of mannite consumed. It should be stated here, however, that the glucose solution was practically free from nitrogen, containing no more than a few hundreds of a milligram of combined nitrogen, while the mannite solution had added to it 1 gr. of soil which contained somewhat less than 1.90 mg. of combined nitrogen, and, naturally, this nitrogen made possible a more vigorous development in the early part of the experiment.

Similar inoculations into other flasks of glucose, containing each 1 gr. of soil, gave for—

Vineland, non-pasteurized	8.42 mg. of nitrogen.
Freehold, non-pasteurized	5.65 " " "
Vineland, pasteurized	3.40 " " "
Freehold, pasteurized	6.94 " " "

[1] Centr. f. Bact. u. Par. II., Vol. VII. (1901), p. 567.

Here, again, the Vineland non-pasteurized material led to a greater fixation of nitrogen than did the corresponding material from the Freehold soil. In this case, however, the latter gave a much larger yield than in Series IV., and namely, 5.65 mg. for two grams of glucose, or 2.88 mg. for every gram of organic matter used, while the material from the Vineland soil gave practically the same yield as in Series IV.

The Freehold pasteurized material again fixed a larger quantity of nitrogen than did the Freehold non-pasteurized, while the Vinelaid pasteurized material also fixed a considerable quantity of nitrogen.

In still another lot, Vineland pasteurized material fixed the following quantities of nitrogen:

Vineland, pasteurized	3.75 mg.
Freehold, pasteurized	4.35 "

The results with bacterial mixtures show considerable variations, as had already been pointed out by Beijerinck. This question will be discussed in greater detail when the studies with pure cultures are presented.

Series V.

In this series a raw culture of Azotabacter from the greenhouse soil was inoculated into a solution of propionate of the following composition:

1,000	cc	H_2O
6	grams	propionic acid.
0.5	"	K_2HPO_4.
0.2	"	Mg. SO_4.
0.02	"	$CaCl_2$.
5	mg.	K NO_3.

This solution was made neutral to phenolphthaleine with NaOH, and distributed in dishes in 100 cc. portions, according to the following scheme:

1..	100 cc.	propionate	solution						
2..	"	"	"	+1 gm $CaCO_3$.	Dish	10.75	cm.	in	diameter
3..	"	"	"	....	"	14.00	"	"	"
4..	"	"	"	+1 gm $CaCO_3$.	"	15.50	"	"	"
5..	"	"	"	....	"	21.00	"	"	"
6..	"	"	"	+1 gm $CaCO_3$.					
7..	"	"	"	....	250 cc. flasks.				
8..	"	"	"	+1 gm $CaCO_3$.					

All of the dishes, which were practically large Petri dishes, were inoculated after sterilization, while 7 and 8, in flasks, were allowed to remain sterile. The difference in the surface exposed in the several dishes was to show the influence of aeration on the fixation of free nitrogen by crude cultures of Azotabacter.

The dishes were sterilized and analyzed at the end of four weeks, and the following amounts of nitrogen found:

1	0.44 mg.
2	1.76 "
3	....
4	2.94 mg.
5	0.59 "
6	3.09 "
7	....
8	....

The results show that there was little, if any, nitrogen fixed where no $CaCO_3$ was used, and that, as the diameter of the dish increased, the fixation was also increased. The amount fixed in 2, 4 and 6 were considerable, since the solution in each case contained only .6 gr. of propionic acid, or, to be more exact, the equivalent amount of propionate.

Fixation of Nitrogen by Pure Cultures.

The first attempts at the isolation of Azotobacter were made with the greenhouse soil, already referred to. Vigorous growth with the predominance of Azotobacter was not difficult to secure in mannite solutions of the following composition:

1,000	cc.	tap water.
0.5	grams	K_2HPO_4.
20.0	"	mannite.

The characteristic raw membrane, described by Beijerinck,[1] usually appeared, as well as the dark-brown pigment. Nevertheless, the isolation of Azotobacter was found to be considerably more difficult than is claimed by Beijerinck, at least of the Azotobacter encountered in the greenhouse soil. When the crude cultures were diluted with sterile distilled water and smeared on sliced beets or potatoes, in Petri dishes, there was always growth. In these cases, however,

[1] l. c.

small bacilli grew so rapidly as to contaminate any Azotobacter growth, where it appeared at all. No satisfactory results could be obtained with agar consisting of—

1,000	cc. tap water.	
0.5	grams K_2HPO_4.	
20.0	"	mannite, or glucose.
20.0	"	agar.

On these media there usually appeared, in two or three days, large spreading colonies, which were raised, transparent and watery in appearance, and composed of small bacilli, to be described later. In some cases dirty white colonies also appeared, and the examination of these occasionally revealed the presence of Azotobacter. Reinoculation from these colonies and further plating failed, however, in bringing about the desired results. Whenever growth appeared on the plates the colonies were either other than those of Azotobacter or of Azotobacter mixed with other organisms. At any rate, whenever considerable growth appeared in mannite or glucose tubes, when these were inoculated from colonies on the agar plates, Azotobacter organisms were always present and were accompanied by other bacteria.

The crude cultures having showed that Azotobacter organisms occur abundantly in Vinelnad soil, some of the latter was placed in a sterile glycerine solution, made up as follows:

1,000	cc. tap water.	
20.0	grams glycerine.	
0.5	"	K_2HPO_4.
0.2	"	$MgSO_4$.
0.2	"	$CaCl_2$.
5	mg. of KNO_3.	

In ten days the liquid was turbid, with abundant white flakes scattered through it. The examination in hanging drop under the microscope showed a predominating number of Azotobacter, a considerable number of long rods and of vibrions. This culture was then reinoculated into a fresh, sterile glycerine solution. Two days later stroke cultures were made from this fresh solution on mannite agar, containing 5 mg. KNO_3 per liter. In three days, at 28° C., at least two kinds of colonies were discernible on the agar plates, and namely, whitish, dense, raised colonies, and raised, watery, trans-

parent colonies. Microscopic examinations showed the first to consist of Azotobacter bacteria, and inoculation was accordingly made into a glucose solution made up like the glycerine, except that the latter was here replaced by the same weight of glucose. Evidence of vigorous growth became apparent in three or four days, and microscopical examination showed an apparently pure culture of an organism occurring as short rods or large cocci, with many of the former actively motile. These were replated three times on mannite agar, and in each case macroscopical, as well as microscopical, examination showed only one kind of colonies and one kind of organisms. Inoculation into meat-extract bouillon left the latter clear, although a very slight precipitate was formed here. Microscopical examination, also, here showed the presence of the same organism. The inoculation into meat-extract bouillon offers a convenient method for determining whether there is contamination by other bacteria, as has been observed also by Gerlach and Vogel.[1] When other bacteria are present the bouillon usually becomes turbid within twenty-four hours. After several reinoculations and platings there was no doubt left as to the purity of the culture, and steps were taken to describe the organisms more or less briefly. As will be seen from the cultural characteristics, it is not identical with Beijerinck's Azotobacter chroococum, and, because of its certain well-defined peculiarities, it was deemed proper to distinguish it from Beijerinck's organism. It was, therefore, called Azotobacter vinelandii, after the locality whence it was derived.

Cultural Characteristics of A. vinelandii.

The mannite and glucose solutions used here were made up as follows:

1,000	cc. tap water.	
0.5	grams	K_2HPO_4. 2
0.2	"	$MgSO_4$.
0.2	"	$CaCl_2$.
20.0	"	mannite, or glucose.
5	mg. of	KNO_3.

NaOH was added to this solution until neutral to phenolphthaleine; the whole was diluted to the proper volume and sterilized.

[1] 1 l. oc. cit.

The solution was used with filter paper by immersing thick strips of the latter in test tubes containing about 10 to 12 cc. of mannite. Only the lower portion of the paper was immersed in the solution, yet the whole was kept moist by the action of capillarity. Plaster strips, made up of 50 per cent. $CaSO_4$ and 50 per cent. bone charcoal, were also used in a similar manner. The mannite and glucose agar were prepared from the above mannite solution by the addition of 2 per cent. of agar, and the bouillon agar was prepared by the addition of 1 per cent. of agar to meat-extract bouillon.

ON MANNITE-AGAR PLATES.

In four days colonies are about 4 mm. in diameter, round, raised, semi-transparent and marmorated, showing concentric structure, with denser whitish center. Deep colonies—white, small, hardly more than 1 mm. in diameter, elliptical to spindle-shaped.

GLUCOSE SOLUTION.

In four days, turbid, flaky deposit, film on surface, creeping up the walls of the tube.

MANNITE SOLUTION.

In four days, cloudy, flaky deposit, flaky particles on surface, yellow pigment, concentrated near surface and gradually diffusing through the liquid when the tube is agitated.

GLUCOSE AGAR STAB.

Surface, white, raised, limited. Depth, narrow cone of growth, reaching not quite to the bottom of the tube.

MANNITE AGAR, STAB.

Surface, white, raised, limited. Depth, narrow cone of growth, reaching almost to the bottom of the tube.

MEAT-EXTRACT BOUILLON.

Clear, very slight deposit.

BOUILLON AGAR, STAB.

Surface, white, raised, glistening. Depth, narrow cone of growth, almost reaching the bottom of the tube.

MANNITE PAPER.

Liquid turbid, with flaky, abundant deposit. Transparent growth on the surface of the paper.

PLASTER.

Liquid turbid, flaky deposit, thick, transparent growth on the lower portion of the plaster.

FERMENTATION TUBES.

Characteristic growth both in glucose and mannite, but no gas production.

POTATO.

Growth limited, raised, dirty white, glistening.

Cultural Characteristics of Other Bacteria Studied.—Bacillus 30.

MANNITE AGAR PLATES.

Surface, colonies raised, whitish, firm, scale-like, with slight depression at the top. Deep, round, elliptical or spindle-shaped; yellowish.

A. Vinlandii $\times$ 1,000.

B. 30 × 1,000.

GLUCOSE SOLUTION.

Slight growth, liquid cloudy, some brittle deposit, britle film, bubbles on surface.

GLUCOSE AGAR, STAB.

Surface, growth thin, round, limited. Depth, narrow cone of growth, reaching almost to the bottom of the tube.

MANNITE AGAR, STAB.

Surface, growth round, raised, limited, semi-transparent. Depth, narrow cone of growth, a few large bubbles in the medium.

MANNITE PAPER.

Liquid cloudy.

BOUILLON AGAR, PLATE.

Surface, colonies round, to round and incised, about 5 mm. in diameter, rather flat, yellowish towards center, the rest having a slight violet tinge. Deep, colonies yellowish, in many instances shaped like arrow-heads, or round to elliptical, with bud-like outgrowths.

BOUILLON AGAR, STAB.

Surface, growth flat, white glistening, spreading. Depth, broad cone, with hazy zone surrounding it.

MEAT-EXTRACT BOUILLON.

Turbid, vigorous growth, flaky deposit.

PLASTER.

Cloudy, flakes, thin growth on the lower portion of the plaster strip.

FERMENTATION TUBES.

Growth in both glucose and mannite with the production of gas. In the mannite tube the amount of gas was three or four times as great as in the glucose.

POTATO.

Growth, dirty-white to brownish, raised, thick, glistening.

Cultural Characteristics of Bacillus 31.

MANNITE AGAR PLATES.

Surface, colonies round, raised, watery, transparent, 3 to 4 mm. in diameter. Deep, white, lenticular.

MANNITE SOLUTION.

In three days cloudy, in ten days a considerable amount of flocculent deposit.

GLUCOSE SOLUTION.

In three days cloudy, in ten days turbid, with flaky deposit.

MANNITE AGAR, STAB.

Surface, round, raised, transparent, spreading. Depth, cone of growth extending to the bottom of the tube.

GLUCOSE AGAR, STAB.

Scarcely any growth.

BOUILLON AGAR, STAB.

Surface, white, round and covering practically the entire surface. Depth, cone extending about two-thirds down the agar.

BOUILLON.

Turbid, deposit, membrane on surface resembling that produced by B. subtilis.

MANNITE PAPER.

Liquid turbid, and a thin, transparent, moist growth on the surface o1 the paper.

PLASTER.

Liquid turbid, with gelatinous deposit, transparent, growth on the plaster surface.

POTATO.

Extensive, dirty-white, raised growth.

FERMENTATION TUBES.

Glucose, liquid in the long arm; cloudy in the short arm, turbid, with flaky, gelatinous material. Mannite, as in glucose, but less in extent. No gas produced.

Cultural Characteristics of Bacillus 32.

MANNITE AGAR PLATES.

Surface, raised, glistening, starchy, with brown pigment towards the center. The deep colonies are shaped like arrow-heads.

MANNITE SOLUTION.

Very slight growth.

GLUCOSE SOLUTION.

Liquid turbid, growth not extensive.

MANNITE AGAR, STAB.

Surface, scarcely any growth. Depth, growth a very narrow cone, extending to the bottom of the tube.

GLUCOSE AGAR, STAB.

Scarcely any growth.

BOUILLON AGAR, STAB.

Surface, growth raised, limited, orange-colored. Depth, fairly narrow cone of growth, extending to the bottom of the tube.

MANNITE PAPER.

Liquid merely cloudy.

PLASTER.

Liquid turbid, gelatinous deposit, and transparent growth on the plaster surface.

POTATO.

Extensive, raised, growth of a deep orange color.

FERMENTATION TUBES.

In both glucose and mannite, growth was very slight. No gas production observed.

The Morphological Characteristics.—Azotobacter vinelandii.

In mannite, cultures show a considerable number of forms, ranging from large rods with rounded ends to spherical organisms. Most of the organisms are actively motile, showing progressive and at times rotatory motility. As the cultures grow older the number of shorter rots increases, and the cells begin to accumulate and store up fat, which appears in small globules throughout the bacterial body and gives it a granular appearance.

On potato, the morphological variations are more considerable than they are on mannite or glucose agar. The rods are here often almost pear-shaped and considerably larger than the average, or the cocci and diplococci may also attain very considerable dimensions. In meat-extract bouillon the growth is slight and is accompanied by the formation of various involution forms. Some of these show slight motility.

No spore formation was observed under any of the conditions tried; and the heating for five minutes at a temperature of 85° was always sufficient to destroy all of the Azotobacter present.

Azotobacter vinelandii stains easily with carbol fuchsin, with the watery solutions of gentian violet, methyl-violet or fuchsin, and without difficulty with Löffler's methylene blue. The latter brings out nicely the difference between the cell-wall and the cell-contents. In staining for flagella Löwit's and Löffler's methods were tried, with indifferent success, and finally a modification of the latter was adopted that gave fairly satisfactory results. The mordant was prepared according to Löffler, as follows: [1]

[1] Laboratory Directions for Beginners in Bacteriology, V. A. Moore, Boston, 1900.

Tannic acid, 20% solution	10	cc.
Sulphate of iron, saturated solution	5	"
Fuchsin, saturated alcoholic solution	1	"

The mordant was carefully filtered two or three times before using, and allowed to act in the cold for five minutes. The cover-glass was then thoroughly rinsed in running water, and carbol fuchsin or watery gentian violet added, and allowed to act, also in the cold, the former for five minutes, the latter for five to ten minutes.

The Production of Pigment.

In mannite solutions A. vinelandii produces a bright yellow pigment, which gradually diffuses downward. The pigment appears the more readily the greater the surface exposed, and the organisms evidently need the presence of a plentiful quantity of atmospheric oxygen for its production. The Azotobacter bacteria which were met with in the greenhouse soil, and also in other soils, and were studied only in impure cultures, also produced a pigment, but it was dark brown, and in other respects much like that produced by Beijerinck's Azotobacter chroococcum. The latter was found to be insoluble in most media, and was decomposed by caustic alkali. The bright yellow pigment produced by A. vinelandii is not taken up by choloroform, ether, carbon disulphide or aniline. It is soluble in alcohol, and is easily destroyed (or at least decolorized) even by weak acids. It is not apparently affected by dilute ammonia, but is slowly destroyed by a potassium hydroxide solution. This pigment is also produced in 2 per cent. solutions of alcohol and glycerine, and in .5 per cent. solutions of propionate. The production of pigment in glucose is slighter than in mannite, and, when in pure culture, A. vinelandii seems to produce no pigment at all in many cases when growing in glucose. In symbiosis with Bacillus 30, A. vinelandii produces much less pigment in mannite than it produces when growing alone, while in glucose solutions the two produce more pigment than is produced here by A. vinelandii alone. Attempts were made to determine the constitution of this pigment, but, unfortunately, the material collected for the purpose was lost in the recent fire.

The Fixation of Free Atmospheric Nitrogen by Pure Cultures of Azotobacter vinelandii.

Series VI.

In order to determine the relation of the atmospheric nitrogen fixed to the surface exposed inoculations were made from a pure culture of A. vinelandii into a glucose solution, composed as follows:

1,000	cc.	tap water.
20	grams	glucose.
0.50	"	K_2HPO_4.
0.20	"	$MgSo_4$.
0.02	"	$CaCl_2$.
~~5.00~~	"	$K\ NO_3$.

.5 mi gr.

NaOH was then added until the reaction was faintly alkaline to phenolphthaleine.

Sterile 100 cc. portions of this solution were distributed in Erlenmeyer flasks, according to the following plan:

Flask 1	100 cc. glucose solution,	250 cc. flask	—Sterile.
" 2	100 " " "	250 " "	Inoculated.
" 3	100 " " "	500 " "	Inoculated.
" 4	100 " " "	1,000 " "	Inoculated.

In six days the several solutions appeared as follows:

1. Clear.
2. Turbid, flaky deposit, flaky particles.
3. " " " " "
4. " " " " "

In ten days these solutions were analyzed, and the following amounts of nitrogen found:

	Amount of Nitrogen Found.	Amount Fixed.
1	0.20 cc. NH_4OH × .003038 = 0.61 mg.	....
2	0.75 " " " " = 2.28 "	1.67 mg.
3	1.25 " " " " = 3.80 "	3.19 "
4	2.80 " " " " = 8.51 "	7.90 "

These tabulations show that the fixation of nitrogen by A. vinelandii increased as the surface exposed also increased. This circumstance is clearly due to two reasons. In the first place, the bacteria of the Azotobacter group are obligate ærobic organisms, and the fixa-

tion of nitrogen takes place where the access of oxygen is greatest; and namely, at the surface of the solution. Where the surface exposed is greatest, there, also, growth is greatest, and where growth is most vigorous, the building of the organic nitrogenous substance in the bacterial bodies is also most active. In the second place, the larger surface exposed places at the disposal of the bacteria not only a greater amount of oxygen, but also a greater amount of gaseous nitrogen, and this is utilized readily when the bacterial growth is vigorous. As has been pointed out, also, the pigment is formed at the surface, and its formation is undoubtedly directly dependent on the supply of oxygen.

Series VII.

Since slight quantities of combined nitrogen promote the initial development of A. chroococcum, as Beijerinck has found it to be the case, and also because of Winogradsky's claim that Clostridium Pasteurianum is very sensitive as to the nature of the combined nitrogen originally present in the solution, it was desirable to study in this connection the behavior of Azotobacter vinelandii.

The experiment in question was arranged as follows:

Flask 1	100 cc. Mannite solution + 1 gr. $CaCo_3$.			
" 2	100 " " " " " "	+ .5 mg.	KNO_3	Sterile.
" 3	100 " " " " " "	+ .5 "	peptone.	
" 4	100 " " " " " "	+ .5 "	NH_4Cl.	
" 5	100 " " " " " "			
" 6	100 " " " " " "			
" 7	100 " " " " " "	+ .5 "	KNO_3	A. vinelandii.
" 8	100 " " " " " "	+ .5 "	peptone.	
" 9	100 " " " " " "	+ .5 "	NH_4Cl.	
" 10	100 " " " " " "	+2.0 "	KNO_3.	
" 11	100 " " " " " "	+2.0 "	peptone.	
" 12	100 " " " " " "	+2.0 "	NH_4Cl.	

In forty-eight hours the several cultures appeared as follows:

1. Clear.
2. Clear.
3. Clear.
4. Clear.
5. Cloudy, floating membrane, yellow pigment.
6. " " " " "
7. " " " not as advanced as 5 or 6.
8. " " " pigment.
9. " " " "
10. " flakes.
11. " " some pigment.
12. " " " "

In eighteen days the several flasks appeared as follows:

1. Clear.
2. Clear.
3. Clear.
4. Clear.
5. Yellow pigment, membrane now sunk to the bottom.
6. " " " " " " " "
7. " " " " " " " "
8. " " " " " " " "
9. " " " " " " " "
10. " " " " " " " "
11. " " " " " " " "
12. " " " " " " " "

On digestion and analysis, the following amounts of nitrogen were found:

	Nitrogen Found.	Nitrogen Fixed.
1...........	0.15 cc. $NH_4OH \times .003012 = 0.45$ mg.	....
2...........	0.15 " " " " =0.45 "	....
3...........	0.15 " " " " =0.45 "	....
4...........	0.15 " " " " =0.45 "	....
5...........	1.40 " " " " =4.22 "	3.77 mg.
6...........	1.50 " " " " =4.52 "	4.07 "
7...........	1.25 " " " " =3.76 "	3.31 "
8...........	1.50 " " " " =4.52 "	4.07 "
9...........	2.05 " " " " =6.17 "	5.72 "
10..........	1.60 " " " " =4.82 "	4.37 "
11...........	1.40 " " " " =4.22 "	3.77 "
12...........	1.55 " " " " =4.67 "	4.22 "

The .5 mg. of KNO_3, peptone, and NH_4Cl in the sterile solutions contained quantities of nitrogen so slight (not more than .25 mg.) that they form an insignificant portion of the total amount found. The results obtained here do not show any appreciable effect of these slight quantities of combined nitrogen on the fixation; 5 and 6, to which no nitrogen was applied intentionally, yielded 3.77 mg. and 4.07 mg., respectively, of combined nitrogen over and above that found in the sterile solutions, or an average of the two of 3.92 mg. of nitrogen; 7 and 8, to which .5 mg. of KNO_3 and .5 mg. of peptone, respectively, were added, yielded on the average of the two, 3.69 mg. over and above the amount contained in the sterile solutions; 9, to which .5 mg. of NH_4Cl was added, yielded the highest amount in the entire series, and namely, 5.72 mg. Nevertheless, it is questionable whether the higher yield in this case was due to the slight

quantity of the ammonium salt added. It is more likely that it was one of those discrepancies which one meets so often in dealing with bacterial cultures. This belief seems justified by the fact that in 12, where 2.0 mg. of NH_4Cl had been added, the amount of nitrogen fixed was only 4.22. On the other hand, the amount of nitrogen fixed in 10, where 2.0 mg. of KNO_3 were used, was 4.37 mg., or about 1 mg. more than in 7, where .5 mg. of KNO_3 were used. The average fixation in 7, 8 and 9, where .5 mg. of the nitrogen compound were added, was 4.37 mg., while the average fixation in 10, 11 and 12, where 2.0 mg. of nitrogen compound were added, was only 4.12 mg. It would seem from this that slight quantities of combined nitrogen, applied as KNO_3, peptone, or NH_4Cl, do not affect appreciably the fixation of nitrogen by A. vinelandii in mannite solutions. It should be added here that the yields were not very high in any case, since the greatest amount fixed—5.72 mg. nitrogen—represents a fixation of only 2.86 mg. per gram of mannite consumed. There is no doubt, however, that the fixation was unfavorably affected by the small surface exposed in the 250 cc. Erlenmeyer flasks.

Series VIII.

In growing A. vinelandii in mannite solutions, in which strips of filter paper had been placed, it was noticed that in the presence of the latter, growth was far more abundant than in the tubes where no paper was present. The question naturally arose whether A. vinelandii is capable of utilizing part of the filter paper as a source of carbon, and whether by its aid it is capable of fixing greater quantities of nitrogen. To decide this point experimentally, the following experiment was arranged:

1......	150 cc.	mannite	solution	+1	gram	$CaCo_3$.	
2......	"	"	"	"	"	"	+2 grams filter paper.
3......	"	"	"	"	"	"	
4......	"	"	"	"	"	"	+2 grams filter paper.

The mannite solution used here contained 5 mg. KNO_3 per liter, and the flasks in this case were the ordinary Jena, round-bottomed flasks, used for the Kjeldahl digestions. At the end of the experiment it was merely necessary to take out the cotton-stopper, to add mercury and sulphuric acid, and proceed with the work as in other

Kjeldahl determinations. In this way it was not necessary to transfer the culture solutions at the end of the experiment, and thus avoid a possible error. After sterilization in the autoclave and cooling, 3 and 4 were inoculated from a pure culture of A. vinelandii, while 1 and 2 were allowed to remain sterile. In forty-eight hours the several flasks appeared as follows:

1. Clear.
2. Clear.
3. Cloudy, floating membrane.
4. Turbid, floating membrane.

In three weeks the solutions in this series were analyzed, and the following amounts of nitrogen were found:

	Nitrogen Found.	Nitrogen Fixed.
1	0.15 cc. NH_4OH × .003012 = 0.45 mg.	....
2	0.65 " " " " = 1.96 "	....
3	4.10 " " " " = 12.35 "	11.90 mg.
4	9.85 " " " " = 29.67 "	27.71 "

It will be seen from the above that the sterile filter paper contained 1.96 mg., less .45 mg., or 1.51 mg. of nitrogen. Comparing the amounts of nitrogen fixed in 3 and 4, we find that in the presence of the filter paper there was fixed in 4 more than twice as much nitrogen as there was fixed in 3. The 150 cc. of the mannite solution contained 3 grams of mannite, hence there were fixed in 3, 3.97 mg. of nitrogen for every gram of mannite consumed. Disregarding for the moment the filter paper as a source of organic carbon, we find that there were fixed in 4, 27.71 mg. of nitrogen for the 3 grams of mannite consumed, or nearly 9.24 mg. of nitrogen for every gram of mannite used. It is pertinent here to ask whether part of the filter paper was hydrolyzed and then used by the bacteria as a source of food. Just at present this question cannot be answered directly, for the studies in this direction have not been completed as yet. There is some indirect evidence, however (as will be seen from the data to be reported here), to show that, without soluble organic compounds, filter paper cannot be utilized by A. vinelandii for its development. It is purely negative evidence in so far as it shows that A. vinelandii cannot grow with filter alone; it does not show conclusively whether the filter paper is attacked in the presence of mannite or of some other soluble non-nitrogenous organic compound.

There is still another point which deserves mention here, and namely, the possible influence of the nitrogen contained in the filter paper. As was stated above, the 2 gr. of filter paper contained 1.51 mg. of combined nitrogen, most probably in the combined form. Is it possible, then, that this nitrogen stimulated the growth of A. vinelandii? Also, on this point, there is no direct evidence on hand, and judgment will have to be withheld until more complete data are collected. As the matter stands at present, there is room for some very interesting speculation. Remembering that the bacteria of the Azotobacter group are almost universally distributed in our arable soils, it becomes of great interest to inquire in how far they may help to add to the soil's store of combined nitrogen. If they fix any nitrogen at all in the soil, and we have every reason to think that they do, they must utilize for that purpose some source of energy, which they can only find in the non-nitrogenous, or, at least, nitrogen-poor, organic portion of the soil. But since much of the organic matter of the soil is made up of cellulose or allied compounds, it naturally becomes proper to ask whether the Azotobacter bacteria are able to utilize that as a source of food and energy. Should the answer be in the affirmative, the question would arise, How are these organisms enabled to attack the insoluble cellulose? Is it by means of some hydrolyzing ferment, produced for the purpose, or is it by the aid of other soil organisms?

Series IX.

In this series, as in the preceding, filter paper was used, together with the mannite. The different proportions of the paper used were intended to show whether there is a point beyond which the increase in the quantity of paper produces no corresponding increase in the amount of nitrogen fixed. The arrangement of the experiment was as follows:

1...............	200 cc. of mannite solution.		
2...............	" " " " "	+½ gram paper.	Sterile.
3...............	" " " " "	+1 "	"
4...............	" " " " "		
5...............	" " " " "	+½ "	"
6...............	" " " " "	+1 "	"
7...............	" " " " "	+2 "	"

There was also added to each flask 1 gr. of $CaCO_3$. In four days the several solutions appeared as follows:

1. Clear.
2. Clear.
3. Clear.
4. Turbid, pigment, surface film, flakes.
5. " " " " "
6. " " " " "
7. " " " " "

At the end of ten days the contents of the flasks were analyzed, and the following amounts of nitrogen found:

	Nitrogen Found.	Nitrogen Fixed.
1	0.15 cc. NH_4OH + .00302 = 0.45 mg.	....
2	0.30 " " " " = 0.91 "	....
3	0.40 " " " " = 1.21 "	....
4	2.30 " " " " = 6.95 "	6.50 mg.
5	3.60 " " " " = 10.87 "	9.96 "
6	3.80 " " " " = 11.48 "	10.27 "
7	3.75 " " " " = 11.32 "	9.81 "

The mannite solution used here was like that used in the other series, except that it contained 15 gr. of mannite per liter, instead of 20 gr. Hence, the 200 cc. of solution contained in each case 3 gr. of mannite. With these 3 gr. of organic substance there were fixed, in 4, 6.50 mg. of nitrogen, or 2.17 mg. of nitrogen for every gram of mannite used up. In 5, where there was ½ gr. of filter paper added to the 200 cc. solution, there was a fixation of 9.96 mg., or of 3.32 mg. for every gram of mannite used up. When the quantity of paper was still further increased, in 6, the amount of nitrogen fixed also increased, and we find here a fixation of 10.27 mg., or of 3.42 mg. of nitrogen per gram of mannite employed.

A still further increase in the quantity of filter paper used not only failed to yield an increased amount of fixed nitrogen, but actually led to a diminution in the amount of nitrogen fixed. Thus, we find in 7 a total fixation of 9.81 mg. of nitrogen, or of 3.27 mg. per gram of sugar consumed. This is slightly less than the amount fixed in 5, where only ½ gr. of filter paper was used. This experiment confirms the results obtained in Series VII., but it also shows that there is a maximum quantity of filter paper that can be advantageously used. Evidently the presence, in 200 cc. of the mannite

solution, of 2 gr. of filter paper was less favorable for the fixation of a maximum amount of nitrogen than the presence in the same solution of only 1 gr. of paper. Larger proportions than 2 gr. of paper to 200 cc. of solution were not tried. It is probable, however, that a further increase in the amount of paper used would still further diminish the fixation of free nitrogen. Now, since cellulose is rather insoluble in water, it seems strange that the presence of a mass of inert material should unfavorably influence the development of A. vinelandii. It must be assumed, for this reason, that the cellulose of the filter paper is not entirely inert; in other words, that part of it is changed to some soluble form or forms. If such solution really does take place, it would be interesting to learn more about it. The unfavorable action of larger quantities of paper may be due, however, to another cause, and namely, to the combined nitrogen contained in it. Reference was already made to Winogradsky's experiment, where his Clostridium Pasteurianum actually caused a loss of nitrogen from the solution when the amount of combined nitrogen added exceeded a certain proportion to the amount of sugar in solution. Also, Beijerinck and van Delden, and Gerlach and Vogel, have observed that larger quantities of combined nitrogen discourage the fixation of free nitrogen by bacteria of the Azotobacter group. It will be seen that 5 contained .46 mg. of combined nitrogen in the filter paper; 6, .76 mg., and 7, 1.51 mg. of combined nitrogen. Also this point is worthy of further study. Further data on the influence of filter paper cellulose on the nitrogen fixation of A. vinelandii may be obtained from Series X.

Series X.

The arrangement of the cultures in this series was as follows:

1...........	100 cc. mineral solution +1 gram paper.	
2...........	" " " " " "	+0.1 gram mannite.
3...........	" " " " " "	+0.2 " "
4...........	" " " " " "	+0.5 " "
5...........	" " " " " "	+1.0 " "
6...........	" " " " " "	+1.5 " "

Two hundred and fifty cc. Erlenmeyer flasks were used in this series, and 1 gr. $CaCO_3$ was also added to each flask. Inoculation of all the flasks was made after the usual sterilization in autoclave and cooling.

In nine days the several solutions appeared as follows:

1.	Slightly cloudy.	
2.	Turbid.	
3.	"	
3.	"	pigment.
4.	"	"
5.	"	"
6.	"	"

Hence there was practically no growth in 1, where filter paper was the only source of organic carbon. In this respect, at least, there is a decisive answer to the question. As the amounts of mannite in the solution increased, the growth became stronger and the pigment production was already pronounced in 4, where mannite was used at the rate of .5 gr. per liter. At the end of twelve days the several solutions were treated according to the Kjeldahl method for nitrogen, and the following amounts were found:

	Nitrogen Found.	Nitrogen Fixed.
1............	0.40 cc. $NH_4OH \times .003020 = 1.21$ mg.	....
2............	0.75 " " " " =2.26 "	1.05 mg.
3............	0.95 " " " " =2.87 "	1.66 "
4............	1.40 " " " " =4.23 "	3.02 "
5............	1.95 " " " " =5.89 "	4.68 "
6............	2.00 " " " " =6.04 "	4.83 "

The greatest proportionate fixation took place in 2 and 4, where 1 gr. and 5 gr., respectively, of mannite per liter were used. This would mean in the latter case a fixation of 6.04 mg. of nitrogen per gram of mannite consumed. As the amount of mannite increased from .5 gr. to 1 gr.—that is, from 5 gr. to 10 gr. per liter—the yield also increased, but not correspondingly. While the increase of mannite was 100 per cent., the increase in the amount of nitrogen fixed was only 53 per cent. A further increase in the amount of mannite in solution, and namely, to 15 gr. per liter, was followed by a further, but not proportionate increase in the amount of nitrogen fixed. In fact, that increase here was but slight. Evidently the increasing amount of organic substance finally begins to retard the fixation of gaseous nitrogen, and, as we have already seen in Series IX., there is a limit not only for the soluble non-nitrogenous organic material, but also for the insoluble nitrogen-poor substance, as represented here by the cellulose of the filter paper. Additional data on this point will be presented later in a similar experiment with A. vinelandii and Bacillus 30.

Series XI.

A number of organic compounds were tried here in order to determine their comparative value as a source of organic carbon to A. vinelandii. The arrangement was as follows:

1..	100 cc. mineral solution	+2 grams ethyl alcohol.	
2..	" " "	+2 grams glycerine.	
3..	" " "	+2 grams mannite + 1 gram soil.	Sterile.
4..	" " "	+1 gram sodium propionate.	
5..	" " "	+1 gram sodium succinate.	
6..	" " "	+1 gram sodium citrate.	
7..	" " "	+2 grams ethyl alcohol.	
8..	" " "	+2 grams glycerine.	
9..	" " "	+2 grams mannite + 1 gram soil.	
10..	" " "	+1 gram sodium propionate.	A. vinelandii.
11..	" " "	+1 gram sodium succinate.	
12..	" " "	+1 gram sodium citrate.	

At the end of three weeks the several cultures appeared as follows:

1-6, both inclusive, remained clear, with no signs of growth The rest all showed more or less growth.

7. Turbid, slight deposit.
8. " moderate deposit, yellowish tinge.
9. " a considerable quantity of deposit, dark yellow.
10. " slight deposit, light yellow tinge.
11. Cloudy, few flakes.
12. Faintly cloudy.

On being analyzed, the following amounts of nitrogen were found:

	Nitrogen Found.	Nitrogen Fixed.
1..........	0.15 cc. NH_4OH × .003020 = 0.45 mg.	....
2..........	0.15 " " " " = 0.45 "	....
3..........	0.65 " " " " = 1.96 "	....
4..........	0.15 " " " " = 0.45 "	....
5..........	0.15 " " " " = 0.45 "	....
6..........	0.15 " " " " = 0.45 "	....
7..........	0.95 " " " " = 2.87 "	2.42 mg.
8..........	1.30 " " " " = 3.93 "	3.48 "
9..........	3.90 " " " " = 11.78 "	9.82 "
10..........	1.20 " " " " = 3.62 "	3.17 "
11..........	0.25 " " " " = 0.75 "	0.30 "
12..........	0.15 " " " " = 0.45 "	....

The highest yield in this series was obtained from 9, where, besides the 2 gr. of mannite, also 1 gr. of soil was added. Because of the addition of the soil, the result in this case is not strictly comparable with those obtained from the others. For all that, A. vinelandii seems to find in mannite a more favorable source of food and energy than in the others. It will also be seen that, next to the mannite, glycerine was the most favorable source of carbon. The amount fixed, while not large, is none the less very considerable. Propionate answered the purpose almost as well, if not better, for it should be remembered that in this case only 1 gr. of propionate was used, as against the 2 gr. of glycerine in the other case. A very appreciable quantity was also fixed in the 2 per cent. solution of ethyl alcohol, while with succinate the growth and fixation were very slight. In the citrate solution there was practically no growth.

This series shows clearly that A. vinelandii, like A. chroococcum, can make use of a great variety of organic compounds for its development. These include, not only higher alcohols and mono-saccharides, but also the salts of the simpler organic acids of the paraffine series and of the lower alcohols. Several other compounds were tried in Series XII., but on account of the fire, already referred to, the observations could not be completed. This series was arranged as follows:

Series XII.

1............	200 cc.	mineral	solution,	+3.0	grams	mannite.
2............	"	"	"	+4.0	"	glucose.
3............	"	"	"	+3.0	"	saccharose.
4............	"	"	"	+3.0	"	maltose.
5............	"	"	"	+3.0	"	lactose.
6............	"	"	"	+3.0	"	dextrin.

In forty-eight hours there was growth in all of the solutions, except that of lactose, which showed no signs of growth. The experiment was interrupted here by unforseen circumstances, and quantitative determinations could not be made here.

Experiments on the Fixation of Atmospheric Nitrogen by Azotobacter Vinelandii and B. 30.

It has been observed, before quantitative determinations were made, that Bacillus 30, when growing together with A. vinelandii, stimulated the growth of the latter. Nitrogen determinations showed that B. 30 can fix for itself only slight quantities of free nitrogen, and it was naturally of great interst to decide just to what extent the latter contributed to the fixation of atmospheric nitrogen when in symbiotic growth with A. vinelandii. A number of experiments were planned and carried out, which show very definitely that, in the presence of Bacillus 30, A. vinelandii is capable of fixing much larger quantities of nitrogen than it is capable of when growing alone.

Series XIII.

This series was so arranged as to show the extent of fixation by A. vinelandii and Bacillus 30 when inoculated together or singly in mannite containing 10 and 20 gr. of mannite per liter. The solutions were kept at room temperature, and there were several nights when it was rather cold in the laboratory (as low as 11° C.), and for this reason growth was retarded. The arrangement of the experiment was as follows:

1......	200 cc.	mineral	solution,	+2	grams	mannite.	
2......	"	"	"	+4	"	"	Sterile.
3......	"	"	"	+2	"	"	A. vinelandii.
4......	"	"	"	+4	"	"	
5......	"	"	"	+2	"	"	A. vin.+B. 30.
6......	"	"	"	+4	"	"	

The mineral solution in 1, 3 and 5 contained only one-half the minerals, and was prepared by diluting the ordinary solution of the mineral salts with as much again of distilled water. One gr. of $CaCO_3$ was also added to each flask. In sixteen days the different flasks appeared as follows:

1. Clear.
2. Clear.
3. Turbid.
4. " flakes.
5. " membrane on surface.
6. " " " " pigment.

The nitrogen determinations, carried out in the usual way, gave the following results:

		Nitrogen Found.	Nitrogen Fixed.
1	0.15 cc. $NH_4OH \times .003020$	=0.45 mg.	....
2	0.15 " " " "	=0.45 "	....
3	0.70 " " " "	=2.11 "	1.66 mg.
4	0.80 " " " "	=2.42 "	1.97 "
5	1.40 " " " "	=4.23 "	3.78 "
6	2.85 " " " "	=8.61 "	8.16 "

It will be seen from these figures that Bacillus 30 had increased the nitrogen-fixing power of A. vinelandii to a remarkable extent. In 3, A. vinelandii fixed only 1.66 mg. of nitrogen, while in 5, where it had the aid of Bacillus 30, 3.78 mg. were fixed, or more than double the amount. Similarly, there were only 1.97 mg. of nitrogen fixed in 4, while in 6 there were 8.16 mg. fixed, or more than four times the amount. Relations no less striking are brought out by other experiments. It would be idle to speculate as to the exact manner in which B. 30 contributes to the fixation of nitrogen by A. vinelandii, for, as long as the mechanism of fixation itself is unknown, it is not an easy matter to explain wherein the favorable action of B. 30 lies. Winogradsky has suggested taht the fixation of atmospheric nitrogen is accomplished in the bacterial body by the union of nascent hydrogen with atmospheric nitrogen to ammonia, and the latter used for further syntheses. It is not impossible that such is really the case. B. 30 may help A. vinelandii, for, as was stated above, B. 30 produces both in mannite and glucose solution a considerable quantity of gas, which consists, in part, at least, of hydrogen.

Series XIV.

This series was arranged to complete Series X., and is presented here accordingly. The arrangement of the entire number of flasks is given. It was as follows:[1]

1	100 cc. mineral solution	+1 gr. filter paper.	
2	" " " "	+1 " " "	+ .1 gr. mannite.
3	" " " "	+1 " " "	+ .2 " "
4	" " " "	+1 " " "	+ .5 " "
5	" " " "	+1 " " "	+1.0 " "
6	" " " "	+1 " " "	+1.5 " "
7	" " " "	+1 " " "	
8	" " " "	+1 " " "	+ .1 " "
9	" " " "	+1 " " "	+ .2 " "
10	" " " "	+1 " " "	+ .5 " "
11	" " " "	+1 " " "	+1.0 " "
12	" " " "	+1 " " "	+1.5 " "

[1] See Series X.

One to 6, both inclusive, were inoculated with A. vinelandii; 7 to 12, both inclusive, were inoculated with A. vinelandii + B. 30. The culture solutions were kept in the incubator at 28° C.

At the end of nine days the several flasks appeared as follows:

1. Cloudiness, faint.
2. Turbid.
3. "
4. " pigment.
5. " "
6. " "
7. Cloudy.
8. Turbid, slight membrane on surface.
9. " " " " "
10. " membrane on surface.
11. " heavy membrane on surface.
12. " " " " "

Also here it appears that there was no pigment production in 9, 10, 11 and 12, although the growth here was more vigorous than in 4, 5 and 6, where pigment was produced. The cultures were analyzed at the end of twelve days, and the following amounts of nitrogen found:

	Nitrogen Found.	Nitrogen Fixed.
1...........	.40 cc. NH_4OH × .003020=1.21 mg.	....
2...........	.75 " " " " =2.26 "	1.05 mg.
3...........	.95 " " " " =2.87 "	1.66 "
4...........	1.40 " " " " =4.23 "	3.02 "
5...........	1.95 " " " " =5.89 "	4.68 "
6...........	2.00 " " " " =6.04 "	4.83 "
7...........	.40 " " " " =1.21 "	....
8...........	.90 " " " " =2.72 "	1.51 "
9...........	1.30 " " " " =3.93 "	2.72 "
10...........	2.40 " " " " =7.25 "	6.04 "
11...........	3.25 " " " " =9.81 "	8.60 "
12...........	3.20 " " " " =9.67 "	8.46 "

The results obtained in solutions 1 to 6 were already discussed under Series X. It remains now to compare the second half of this series with the first half of it. It will be seen that in every case where Bacillus 30 was inoculated, together with A. vinelandii, there was an increase in the amount fixed over and above that yielded by A. vinelandii alone. Culture solution 7 should be excepted, of course, for no appreciable fixation of nitrogen took place there. In order to

bring out these relations still more clearly, the corresponding solutions are arranged parallel to one another:

	Fixation by A. vinelandii.		By A. vinelandii + B. 30.		
2	1.05 mg.	8	1.51 mg.	increase	43.8 %
3	1.66 "	9	2.72 "	"	63.8 "
4	3.02 "	10	6.04 "	"	100.0 "
5	4.68 "	11	8.60 "	"	83.7 "
6	4.83 "	12	8.46 "	"	75.1 "

The greatest proportionate fixation was here in 2 and 8, respectively. As the amount of mannite increased, the proportionate fixation decreased. There were fixed per gram of mannite consumed, the following quantities of nitrogen:

2	10.50 mg.	8	15.10 mg.
3	8.30 "	9	13.60 "
4	6.04 "	10	12.08 "
5	4.68 "	11	8.60 "
6	3.22 "	12	5.64 "

It is but natural that, with a smaller quantity of food in solution, the bacteria should utilize it more thoroughly and thus reduce the waste to a minimum. The experiment of Gerlach and Vogel, cited in the first part of this paper, confirms the above results. There is a very close analogy here to the utilization of combined nitrogen in the soil by higher plants. The greater the amount of it there is present in the soil, the slighter the proportionate utilization of it within given limits. In this case the presence of Bacillus 30 enabled a more economical use of the organic substance in solution; nevertheless, even with the two organisms working together, there was a gradual decrease in the proportionate amount of nitrogen consumed. On the average, the presence of Bacillus 30 enabled A. vinelandii to fix 73.3 per cent. more nitrogen. The minimum is 43.8 per cent. in 8, and the maximum, 100 per cent. in 10.

Series XV.

This series resembles somewhat Series IX., except that starch was used here instead of filter paper, and that Bacillus 30 was also inoculated in some of the flasks. The experiment was arranged as follows:

1...	200 cc.	mineral	solution	+ 3.0 gr.	mannite.			
2...	"	"	"	" "	"	+ .5 gr. starch.		Sterile.
3...	"	"	"	" "	"	+ 1.0 "	"	Sterile.
4...	"	"	"	" "	"	+		A. vinelandii.
5...	"	"	"	" "	"			A. vin. + B. 30.
6...	"	"	"	" "	"	+ .5 "	"	A. vinelandii.
7...	"	"	"	" "	"	+ .5 "	"	A. vin. + B. 30.
8...	"	"	"	" "	"	+ 1.0 "	"	A. vinelandii.
9...	"	"	"	" "	"	+ 1.0 "	"	A. vin. + B. 30.
10...	"	"	"	" "	"	+ 1.0 "	paper.	A. vin. + B. 30.

In each case there was also added 1 gr. of $CaCO_3$. The solutions were sterilized in the autoclave in the usual way. The high temperature of sterilization (about 130° C.) undoubtedly made soluble part of the starch, and this fact should be borne in mind in the interpretation of the results. On cooling, the flasks were inoculated with the corresponding cultures and placed in the incubator at 28° C.

In four days the several flasks appeared as follows:

1.	Clear.					
2.	"					
3.	"					
4.	Turbid,	slight,	membrane,	flakes,	pigment.	
5.	"	"	"	"	"	(slight).
6.	"	"	"	"	"	
7.	"	membrane,	heavier, but	pigment	slight.	
8.	"	"	moderate,	pigment.		
9.	"	"	heavy,	"	slight.	
10.	"	"	"	"	"	

The analysis at the end of ten days showed the following quantities of nitrogen:

			Nitrogen Found.	Nitrogen Fixed.
1	.15 cc.	$NH_4OH \times .003020$ =	.45 mg.	......
2	.20 "	" " =	.60 "	....
3	.25 "	" " =	.75 "	....
4	1.90 "	" " =	5.74 "	5.29 mg.
5	3.15 "	" " =	9.51 "	9.06 "
6	2.65 "	" " =	8.00 "	7.40 "
7	3.75 "	" " =	11.32 "	10.72 "
8	1.95 "	" " =	5.89 "	5.14 "
9	3.55 "	" " =	10.42 "	9.67 "
10	4.40 "	" " =	13.29 "	12.54 "

We see, also, in this experiment a diminution in the amount of nitrogen fixed when the organic substance added exceeds a given proportion. The maximum limit in this case seems to have been somewhere between .5 and 1.0 gr. of starch to 200 cc. of the mannite solution, containing 3 gr. of mannite. Arranging the amounts fixed by A. vinelandii and A. vinelandii + B. 30, respectively, in parallel columns, we have thus brought out quite clearly—

Nitrogen fixed by A. vinelandii.	Nitrogen fixed by A. vinelandii + B. 30.
4–5.29 mg.	5–9.06 mg.
6–7.40 "	7–10.72 "
8–5.14 "	9–9.67 "

We note an increase from 4 to 6 of 2.11 mg., and a decrease from 6 to 8 of 2.26 mg.; in other words, the increase from the addition of 5 gr. of starch to the 200 cc. solution was almost equal to the decrease caused by the addition of an equal quantity of starch when the solution already contained .5 gr. of it. Similarly, we note an increase from 5 to 7 of 1.66 mg., and a decrease from 7 to 9 of 1.05 mg. Also here 1 gr. of starch led to a slighter fixation than .5 gr. of starch. As in other series, the presence of B. 30 enabled A. vinelandii to fix greater amounts of free nitrogen. Comparing 4 and 5, solutions of the same composition, we find that there were fixed, in the latter, 71.3 per cent. more of nitrogen than in the former. In 7 there were 44.9 per cent. more of nitrogen fixed than in 6, and in 9, 88.1 per cent. more than in 8. These results show that, aside from the increased fixation, the presence of B. 30 also enables A. vinelandii to withstand better the presence of excessive quantities of organic matter. Hence, it would appear that the accumulation of large quantities of organic matter in the soil, be it rich or poor in nitrogen, unfavorably affects the development of Azotobacter bacteria. When there is an accumulation of large quantities of nitrogen-rich substances, the growth of these organisms practically stops; when there is an accumulation of nitrogen-poor organic substance, the growth of these organisms is retarded. But since, in all arable soils, many bacterial species act and interact on one another, and the development of any particular combination may become prominent at one time, and that of another at another time, it is clear that the conditions of fixation in the soil are, perforce, somewhat different than they are in artificial cultures. None the less, these experiments

show unequivocally that, for its best work, A. vinelandii, and undoubtedly also other members of the Azotobacter group, must depend on the co-operation of other organisms.

Series XVI.

This series is complimentary, in a way, to Series XVII., and was carried out with a pure culture of A. vinelandii. It was intended to study the effect of fixation of a large surface exposed. For this reason the mannite solution employed here was placed in large crystalizing dishes, covered in the manner of ordinary Petri dishes. The arrangement in this series was as follows:

1.........	Large Erlenmeyer flask,	300 cc.	mannite solution.	Sterile.
2.........	" Petri dish,	300 "	" "	
3.........	" " "	500 "	" "	A. vinelandii.

The internal diameter of the dish in 2 was 27 cm., and in 3, 29 cm. The mannite solution contained 15 gr. of mannite per liter, hence 1 and 2 contained 4.5 gr. of mannite each, and 3 contained 7.5 gr. of mannite. After sterilization, cooling and inoculation in the usual manner, the dishes were placed in the incubator at a temperature of 28° C. In both of the inoculated dishes growth was apparent in twenty-four hours. In forty-eight hours there was the development of the bright yellow pigment and of the characteristic membrane on the surface. As it grew older, the membrane gradually grew thicker. On examination under the microscope it was found that A. vinelandii alone was present, and hence there had been no contamination from the outside. The contents of the dishes and of the flask were analyzed at the end of six days, and the following amounts of nitrogen were found:

	Nitrogen Found.	Nitrogen Fixed.
1......................	.20 cc. $NH_4OH \times$ .003020 = .60 mg.	....
2......................	9.55 " " " " =28.84 "	28.24 mg.
3......................	17 40 " " " " =52.55 "	51.95 "

During digestion, part of the solution in 2 was lost, and the amount given here is undoubtedly somewhat too low. While the loss is not believed to have been very considerable, it undoubtedly amounted to 2 or 3 mg. Leaving 2 out of consideration, we note that there were

51.95 mg. of nitrogen fixed in 3; hence there was a fixation of 6.8 mg. of nitrogen for every gram of mannite consumed. This is a very considerable quantity for a period of 6 days, and by a pure culture of A. vinelandii. These results were obtained with a culture which had been reinoculated into artificial solutions a considerable number of times, and they show that A. vinelandii does not lose its nitrogen-fixing power as some of the other organisms to be discussed later.

Series XVII.

The culture solutions in this series were arranged as follows:

1..........	200 cc. mannite solution in Erlenmeyer flask	+ 1 gr. filter paper.
2	200 " " " " large Petri dish	+ 1 gr. " "
3.........	200 " " " " " " "	+ 1 gr. " "

No. 1 was left sterile, 2 was inoculated with A. vinelandii, and 3 with A. vinelandii + B. 30. There was also added in each case 1 gr. of $CaCO_3$.

At the end of ten days the several solutions were analyzed and the following amounts of nitrogen were found:

	Nitrogen Found.	Nitrogen Fixed.
1.....................	.15 cc. $NH_4OH \times .002020 =$ .45 mg.	....
2	9.90 " " " " =29.90 "	29 45 mg.
3	10.15 " " " " =30.65 "	30.20 "

The solutions contained at the beginning of the experiment 3.0 gr. of mannite in each case, so that there was fixed in 2, 9.81 mg. of nitrogen for every gram of mannite consumed. Similarly, there were fixed in 3, 10.07 mg. of nitrogen for every gram of mannite consumed. These are the highest yields thus far obtained with 15 gr. of mannite per liter. The presence of B. 30 increased the yield also in this case, although the increase was rather small.

Fixation of Nitrogen by A. Vinelandii in the Presence of Other Bacteria.

These studies include experiments with a number of organisms. The purpose of these experiments was to determine whether there are bacteria other than B. 30 that would favor the fixation of free nitrogen by A. vinelandii.

Series XVIII.

The solutions employed in this series contained, besides the customary amounts of the mineral salts, either 20 gr. of mannite or of glucose per liter of solution. Two hundred cc. portions of these solutions were distributed in Kjeldahl flasks, with the addition in each case of 1 gr. of $CaCO_3$. The organisms used in this series were A. vinelandii, B. pyocyaneus, B. 31, B. 30, B. 31 variety and B. 32. The arrangement of the experiment was as follows:

1. Glucose solution.		Sterile.
2. Mannite	"	
3. Glucose	"	A. vinelandii.
4. Mannite	"	
5. Glucose	"	A. vinelandii + B. pyocyaneus.
6. Mannite	"	
7. Glucose	"	A. vinelandii + B. 31.
8. Mannite	"	
9. Glucose	"	A. vinelandii + B. 30.
10. Mannite	"	
11. Glucose	"	A. vinelandii + B. 31 var.
12. Mannite	"	
13. Glucose	"	A. vinelandii + B. 32.
14. Mannite	"	

In three days the several cultures appeared as follows:

1.	Clear.			
2.	....			
3.	Cloudy, flakes, deposit.			
4.	Moderately turbid, membrane, pigment.			
5.	Turbid, film on surface.			
6.	"	membrane, pigment.		
7.	"	"		
8.	"	"	"	
9.	"	"	deposit.	
10.	"	"	"	pigment.
11.	"	"	"	
12.	"	"	"	"
13.	"	"	"	"
14.	"	"	"	"

At the end of eight days the cultures were analyzed, and the following amounts of nitrogen found:

		Nitrogen Found.	Nitrogen Fixed.
1	.25 cc. $N.H_4OH$ + .003038 =	.76 mg.	....
2	.15 " " " " =	.45 "	......
3	1.35 " " " " =	4.10 "	3.34 mg.
4	1.45 " " " " =	4.40 "	3.95 "
5	1.55 " " " " =	4.71 "	3.95 "
6	.90 " " " " =	2.73 "	2.28 "
7	1.55 " " " " =	4.71 "	3.95 "
8	1.55 " " " " =	4.71 "	4.26 "
9	3.25 " " " " =	9.87 "	9.11 "
10	3.55 " " " " =	10.78 "	10.33 "
11	1.55 " " " " =	4.71 "	3.95 "
12	1.85 " " " " =	5.62 "	5.17 "
13	1.35 " " " " =	4.10 "	3.34 "
14	1.95 " " " " =	5.92 "	5.47 "

These results show that, with one exception, there was more nitrogen fixed in the mannite solutions than there was in the glucose solutions. They also show that B. 30 was the only organism of those tried in the series to increase the fixation of nitrogen by A. vinelandii to any considerable extent. Thus, A. vinelandii alone fixed, in glucose, 3.34 mg. of nitrogen, and in mannite 3.95 mg. of nitrogen. In the presence of B. 30 the corresponding amounts were 9.11 mg. and 10.33 mg., or more than 2.5 times as great. It also seems that, in 12 and 14, there was a marked increase in the amount of nitrogen fixed, due to the presence, in 12, of B. 31 var., and in 14 of B. 32. Other experiments with B. 32, to be reported elsewhere, show that, under certain conditions, this organism is capable by itself of fixing small quantities of nitrogen.

Series XIX.

Experiments on the Fixation of Free Nitrogen by a Combination of More than Two Organisms.

The arrangement of this series was as follows:

1. A. vinelandii.
2. B. 30.
3. B. 31.
4. B. 32.
5. B. 33.
6. A. vinelandii + B. 30.
7. " + B. 30 + B. 31.
8. " + B. 30 + B. 31 + B. 32.
9. " + B. 30 + B. 31 + B. 32 + B. 33.

There was used in each case a 100 cc. mannite solution, diluted to 200 cc. by the addition of distilled water. This, of course, made the mannite solution of slighter concentration, not only as regards the mannite, but also in respect to the mineral salts.

At the end of fifteen days the different flasks in this series appeared as follows:

1. Turbid, flakes, flaky deposit.
2. Cloudy.
3. Cloudy, slightly flaky deposit.
4. Clear, some flaky deposit.
5. Clear.
6. Turbid, film, deposit.
7. " " "
8. " " " pigment.
9. " " " "

At the end of twenty-two days the culture solutions were analyzed with the following results:

	Nitrogen Found.					Nitrogen Fixed.
1	1.60 cc.	NH_4OH	$\times$	.003020	= 4.83 mg.	4.38 mg.
2	.35 "	"	"	"	= 1.06 "	.61 "
3	.15 "	"	"	"	= .45 "	....
4	.20 "	"	"	"	= .60 "	Traces.
5	.20 "	"	"	"	= .60 "	"
6	3.05 "	"	"	"	= 9.21 "	8.76 mg.
7	2.85 "	"	"	"	= 8.61 "	8.16 "
8	3.25 "	"	"	"	= 9.81 "	9.36 "
9	3.70 "	"	"	"	=11.17 "	10.72 "

Of the organisms tried here, A. vinelandii fixed large quantities of nitrogen, and B. 30 showed a slight, but unmistakable nitrogen-fixing power. B. 32 and B. 33 made some growth and fixed mere traces of nitrogen. When the different organisms were used in combination, B. 30, together with A. vinelandii, again showed a high efficiency in the fixation of nitrogen when growing alone; the presence of B. 30 in 6 enabled it to fix 8.76 mg. of nitrogen, or exactly double the amount. The addition of B. 31 to this combination reduced somewhat the amount of nitrogen fixed. A still further addition of B. 32 gave a slight increase, and the addition of B. 33 gave a further increase. B. 33, which has not been described here, is a granular, motile organism, seemingly capable of fixing very considerable quantities of atmospheric nitrogen in the presence of a long, slender bacillus,

whose isolation in pure culture has not been accomplished thus far. In the crude cultures of A. vinelandii, B. 33 is often found, especially in the older cultures, for its development is rather slow. B. 33 was also found to occur even to a greater extent in the crude cultures of an Azotobacter organism encountered in the greenhouse soil already referred to. On the whole, B. 31 and B. 32, while accompanying tenaciously the nitrogen-fixing bacteria, seem incapable of increasing to any great extent their nitrogen-fixing power.

The Fixation of Nitrogen by A. Vinelandii when Together with the Bacteria of Pasteurized Soil.

Series XIX.

Beijerinck obtained some of his best results by the use of A. chroococcum, together with pasteurized soil. Evidently the spore-bearing bacteria in the latter helped A. chroococcum to fix atmospheric nitrogen, although this organism is incapable of doing it by itself. A. vinelandii is different in this respect, in that it can fix free nitrogen without the aid of other bacteria. At the same time it was interesting to determine the extent to which this fixation is favored by pasteurized soil from different sources. In the experiment presented here three pasteurized soils were used, and namely, Freehold pasteurized, Vineland pasteurized and College Farm pasteurized. The experiment was arranged as follows:

1. 200 cc. mannite solution—A. vinelandii.
2. " " " —A. vin. + Vineland pasteur. soil.
3. " " " —A. vin. + Freehold pasteur soil.
4. " " " —A. vin. + College Farm pasteur. soil.

Each solution had also added to it 1 gr. of $CaCO_3$. In two weeks the golden yellow pigment appeared prominently only in 2. The microscopical examination in hanging drop showed the presence of A. vinelandii alone in 1. In 2 there were also found long, slender rods, producing drum-stick like forms, because of the thickening of one end by spore formation. There were also observed a few spores situated in a triangular sheath, like that described by Winogradsky for Clostridium Pasteurianum. Besides these there were also seen some long, thick, granulated rods and small bacilli. In 3 there were found, besides A. vinelandii, long, slender rods, many small, round

spores and a few thicker rods. In 4 the number of organisms was greater than in the others; A. vinelandii and long rods, like those in 3, were prominent.

The analysis of these cultures for nitrogen gave the following results:

	Nitrogen Found.	Nitrogen Fixed.
1. 2.25 cc. $NH_4OH \times .003020$	= 6.79 mg.	6.34 mg.
2. 5.15 " " " "	= 15.65 "	15.20 "
3. 3.75 " " " "	= 11.32 "	10.87 "
4. 4.65 " " " "	= 14.04 "	13.59 "

The addition of pasteurized soil helped in every case the fixation of atmospheric nitrogen. Where A. vinelandii was able to fix only 6.34 mg. of nitrogen, the addition of the bacteria from the pasteurized Vineland soil increased the yield to 15.20 mg. The Freehold pasteurized soil increased the yield to 10.87 mg., and the College Farm pasteurized soil to 13.59 mg. of nitrogen. It is interesting to note that the greatest increase was obtained in 2, where the spore-bearing bacteria of the same soil were employed from which A. vinelandii was isolated. This soil, while sandy in character, and containing only .055 per cent. of nitrogen, is, nevertheless, a good, fertile soil; and it is not at all improbable that A. vinelandii and the bacteria growing in symbiosis with it contribute materially to the nitrogen store from which the crops obtain their supply.

Behavior of A. Vinelandii, B. 30 and A. Vinelandii and B. 30 in Meat-Extract Bouillon.

Series XX.

It was already stated above that A. vinelandii makes but slight growth in meat-extract bouillon, while B. 30 seems to develop normally in such bouillon. In order to determine the quantitative relation of these organisms to the soluble nitrogen of the bouillon, the following experiment was arranged:

1. 25 cc. meat-extract bouillon.	Sterile.
2. " " " "	
3. " " " "	A. vinelandii.
4. " " " "	
5. " " " "	B. 30.
6. " " " "	
7. " " " "	A. vinelandii + B. 30.
8. " " " "	

The bouillon was placed in the round-bottomed Jena flasks used for the Kjedahl digestions, so that no transferring was necessary at the end of the experiment. At the end of twelve days the several cultures appeared as follows:

1.	Clear.
2.	"
3.	Moderately cloudy, very slight deposit.
4.	" " " "
5.	Turbid, some deposit, flakes in liquid.
6.	" " " " " "
7.	Strong turbidity, " " " deposit.
8.	" " " " " "

Series XX.a.

The growth of B. 30 in bouillon resulted in two months in a considerable loss of nitrogen. Fifty cc. of meat-extract bouillon were placed in each of three flasks, and, after sterilization and cooling, 2 and 3 were inoculated with B. 30, while 1 was left sterile. At the end of two months the nitrogen in each flask was determined, and the following amounts were found:

1	58.91 mg.
2	48.30 "
3	47.58 "

It is evident that in the comparatively long period the losses were quite considerable. In 2 there was a loss of 10.61 mg., and in 3 there was a loss of 11.33 mg. of nitrogen. It will be seen from other experimental series that B. 30 is capable of fixing small quantities of atmospheric nitrogen, and, in nutrient malate solutions, it is capable of fixing considerable quantities of nitrogen, so that its behavior is in many respects similar to that of B. pyocyaneus, as it was already noted elsewhere.[1] At the same time, B. 30 differs markedly from B. pyocyaneus in its relation to the organism of the Azotobacter group, since B. pyocyaneus does not stimulate the fixation of nitrogen by the Azotobacter organisms.

[1] N J. Sta. Rep., 1902, p. 235.

Series XX.b.

It was attempted to determine in this series in how far small quantities of combined nitrogen will stimulate the growth of B. 30 in mannite solutions containing the proper amounts of the mineral salts. The arrangement of this series was as follows:

1. 200 cc.	mannite	solution	+ 10 mg	peptone.	Sterile.
2. 200 "	"	"	+ 1 "	"	B. 30.
3. 200 "	"	"	+ 5 "	"	B. 30.
4. 200 "	"	"	+ 10 "	"	B. 30.

There was slight growth in all of the inoculated solutions. At the end of four weeks the several cultures were alalyzed, and the following amounts of nitrogen were found:

1. 1 30 cc.	NH_4OH	containing	.0013071	gr. N.	per cc.	= 1.70 mg.
2. 1.45 "	"	"	"	"	"	= 1.89 "
3. 1 60 "	"	"	"	"	"	= 2.09 "
4. 2.20 "	"	"	"	"	"	= 2 87 "

The mannite solution, less the peptone, has been found to contain .40 to .45 mg. of nitrogen; hence the 10 mg. of peptone in 1 probably contained 1.30 mg. of nitrogen, the 1 mg. of peptone in 2 contained 0.13 mg. of nitrogen, and the 5 mg. of peptone in 3 contained 0.65 mg. of nitrogen. Making due allowance for the combined nitrogen originally present in each flask, we obtain the following results:

	Nitrogen Originally Present.	Nitrogen Fixed.
1.	1.70 mg.	....
2.	0.53 "	1.36 mg.
3.	1.05 "	1 04 "
4.	1.70 "	1.17 "

It appears from the above that 1 mg. of peptone enabled B. 30 to fix more nitrogen than 10 mg. of peptone, although the differences here are not very considerable. At the same time there was evidently in each case a decided addition to the amount of combined nitrogen originally present in solution.

Series XX.c.

The sodium salts of succinic, of malic and of tartaric acid were used in this series as the only organic compound, and it was the purpose of the experiment to determine whether B. 30 and A. vinelandii would grow in such solutions, either singly or together. The mineral solution was prepared as usual—10 gr. per liter of the corresponding acid were dissolved in water and a ten per cent. solution of sodium hydroxide added until the liquid was faintly alkaline to phenolphthaleine. The two solutions were then mixed, the entire mixture remaining slightly acid to phenolphthaleine because of the K_2HPO_4 present. The arrangement of this series was as follows:

1. 200 cc. mineral solution.					Sterile.
2. 200 "	"	"	containing	2 gr. succinic acid.	Sterile.
3. 200 "	"	"	"	2 gr. succinic acid.	
4. 200 "	"	"	"	2 gr. malic acid.	B. 30.
5. 200 "	"	"	"	2 gr. tartaric acid.	
6. 200 "	"	"	"	2 gr. succinic acid.	
7. 200 "	"	"	"	2 gr. malic acid.	A. vinelandii.
8. 200 "	"	"	"	2 gr. tartaric acid.	
9. 200 "	"	"	"	2 gr. succinic acid.	
10. 200 "	"	"	"	2 gr. malic acid.	A. vinelandii + B. 30.
11. 200 "	"	"	"	2 gr. tartaric acid.	

Three days after inoculation, 1 and 2 remained clear; 3, 4 and 5 were cloudy; 6, 7 and 8 were clear, and 9, 10 and 11 were cloudy. At the end of three weeks 1 and 2 were still clear; 3 was cloudy and contained a slight deposit; 4 was strongly cloudy and contained a membrane deposit; 5 was sligtly cloudy; 6 contained a hevy membrane, and was of a cherry red color; 7 was turbid; 8, cloudy; 9, turbid, with heavy membrane and yellowish pigment; 10, turbid, membrane and pink pigment, and 11 was merely cloudy. The following amounts of nitrogen were found by analysis:

		Nitrogen Found.	Nitrogen Fixed.
1.	.15 cc. NH_4OH containing .0013071 gr. N. per cc. =	.20 mg.	....
2.	.20 " " " " " " =	.26 "	....
3.	.40 " " " " " " =	.52 "	0.29 mg.
4.	2.85 " " " " " " =	3.72 "	3.49 "
5.	.35 " " " " " " =	.46 "	0.23 "
6.	9.05 " " " " " " =	11.83 "	11.60 "
7.	5.95 " " " " " " =	7.78 "	7.55 "
8.	2.20 " " " " " " =	2.87 "	2.64 "
9.	9.90 " " " " " " =	12.94 "	12.71 "
10.	11.45 " " " " " " =	14.97 "	14.74 "
11.	1.80 " " " " " " =	2.35 "	2.12 "

The above tabulation shows that there was more or less fixation in the succinate, malate and tartarate solutions. Arranging the three solutions according to their inoculation, we find the following:

Nitrogen Fixed.	In the Succinate Solution.
B. 30	0.29 mg.
A. vinelandii	11.60 "
A. vinelandii + B. 30	12.71 "

	In the Malate Solution.
B. 30	3.49 mg.
A. vinelandii	7.55 "
A. vinelandii + B. 30	14.74 "

	In the Tartarate Solution.
B. 30	0.23 mg.
A. vinelandii	2.64 "
A. vinelandii + B. 30	2.12 "

The highest amount of nitrogen fixed by B. 30 was in 4, where the sodium malate was used. On the other hand, the amounts of nitrogen fixed in the succinate and tartarate solutions were slight. It is interesting to note that malic acid, which does not differ much in composition from either succinic or tartaric acid, enabled B. 30 to fix the very considerable quantity of 3.49 mg. of nitrogen, while the latter made possible only a scanty growth.

A. vinelandii fixed the greatest amount of nitrogen in the succinate solution, and namely, 11.60 mg. of nitrogen. The fixation in the malate amounted to 7.55 mg., and in the tartarate, to 2.64 mg. As with B. 30, the tartarate was the least favorable of the three for the fixation of nitrogen, although A. vinelandii was enabled to fix here 2.64 mg.

When the two organisms were inoculated together the malate solution proved to be the most suitable for the fixation of nitrogen. These were fixed here with the 2 gr. of malic acid, 14.74 mg. of nitrogen, or 7.37 mg. per gram of the acid used. The succinate solution enabled the two organisms to fix 12.71 mg. of nitrogen, while the fixation in the tartarate was even less than that fixed in the same solution by A. vinelandii alone. It also appears that in both the succinate and the malate the joint fixation by the two organisms was greater than the sum of the amounts fixed by them when growing alone. Thus, in the succinate there were fixed 0.29 mg. and 11.60 mg., respectively, by B. 30 and A. vinelandii, or, in all, 11.89 mg., while the amount fixed by the two in the same culture solution was 12.71. A still greater difference is observable in the malate solutions, where the organisms fixed, when growing singly, 11.04 mg. of nitrogen, and, when growing together, they fixed 14.74 mg.

Comparing the constitutional formulæ of the three acids, and namely,

H **Succinic Acid.**	H **Malic Acid.**	H **Tartaric Acid.**
|	|	|
CH COOH.	CH COOH.	C (OH) COOH.
|	|	|
CHCOOH.	C (OH) COOH.	C (OH) COOH.
|	|	|
H	H	H

We find that the replacement of one of the hydrogen atoms in sodium succinate by hydroxyl renders the resulting compound more favorable for the growth of B. 30 and less favorable for the growth of A. vinelandii. A further replacement of hydrogen by hydroxyl renders the resulting compound less favorable for the growth of either organism.

Series XX.d.

Distilled water, instead of tap-water, was used in this series for making up the nutrient solution. The mineral salts added here were, as usual, K_2HPO_4, $MgSO_4$, $CaCl_2$, traces of KNO_3, also NaOH was used to neutralize the K_2HPO_4. Iron was added or left out, it being the purpose of this series to determine the influence of iron in the fixation of nitrogen by A. vinelandii. The arrangement of this series was as follows:

1. 200 cc. mannite solution.		Sterile.
2. " " "		A. vinelandii.
3. " " "	+ 1 drop Fe_2Cl_6.	"
4. " " "	+ 1 " "	"
5. " " "	+ 2 " "	"
6. " " "	+ 5 " "	"

In three weeks the appearance of the several culture solutions was as follows:

1. Clear.
2. Cloudy, light yellow pigment.
3. Pigment intense, abundant membranous growth.
4. " " " " "
5. " " " " "
6. " " " " "

The several solutions were analyzed at the end of four weeks, and the following amounts of nitrogen were found:

		Nitrogen Found.	Nitrogen Fixed.
1.	.20 cc. NH_4OH containing .0013071 gr. N. per cc. =	0.26 mg.	....
2.	1.70 " " " " " " =	2.22 "	1.96 mg.
3.	10.40 " " " " " " =	13.59 "	13.33 "
4.	10.15 " " " " " " =	13.27 "	13.01 "
5.	12.15 " " " " " " =	15.88 "	15.62 "
6.	13.15 " " " " " " =	17.19 "	16.93 "

There was a decided difference in the intensity of pigment from 2 to 3 and 4, and from these, to 5 and to 6. The pigment in 2 was a light, golden yellow, in the others it was more intense, until in 6 it was a yellowish-red. There was a corresponding increase in the nitrogen fixed. Without the addition of Fe_2Cl_6 in 2, there was a fixation

of only 1.96 mg. of nitrogen. Where one drop of Fe_2Cl_6 was added the fixation was 13.33 and 13.01, respectively, for 3 and 4. With two drops of Fe_2Cl_6 in 5, the fixation increased to 15.62 mg., and with five drops of Fe_2Cl_6 in 6, there was a further increase to 16.93 mg. of nitrogen. It would follow from the above that the addition of some compound of iron is necessary in order to secure the best development of A. vinelandii.

Series XX.e.

It was intended to determine in this series in how far the filter paper added to the mannite solution may serve as a source of energy to A. vinelandii and to B. 30, when growing singly or together. The arrangement of this series was as follows:

1.	200 cc. mannite solution + 1 gr. filter paper.	Sterile.
2.	" " " " " "	
3.	" " " " " "	B. 30.
4.	" " " " " "	
5.	" " " " " "	A. vinelandii.
6.	" " " " " "	
7.	" " " " " "	B. 30 + A. vinelandii.
8.	" " " " " "	

In five days there was the production of the characteristic pigment in 5 and 6, and the appearance of bubbles in 3, 4, 7 and 8, due to the gas formation in the mannite solution by B. 30. The several cultures were analyzed at the end of four weeks and the following amounts of nitrogen were found:

1.	.25 cc.	NH_4OH containing .0013071 gr. N. per cc.	= 0.32 mg.
2.	.20 "	" " " " "	= 0.26 "
3.	1.15 "	" " " " "	= 1.50 "
4.	1.00 "	" " " " "	= 1.31 "
5.	9.00 "	" " " " "	= 11.76 "
6.	8.75 "	" " " " "	= 11.44 "
7.	16.95 "	" " " " "	= 23.15 "
8.	16.50 "	" " " " "	= 21.57 "

The above results show that B. 30 was enabled to fix small quantities of nitrogen in the mannite solutions; that A. vinelandii fixed very considerable quantities of nitrogen, and that the fixation was almost doubled when the two organisms were inoculated together. The strips of filter paper, which were removed from each flask before digestion with sulphuric acid, were carefully washed, dried and weighed, and it was found that there was no decrease in the weight of the paper, from which it must be concluded that, whatever the favorable influence of the filter-paper cellulose may be due to, it is not due to its serving as a source of food and energy.

Series XX.f.

Various organic compounds were used in this series in order to ascertain their relative availability as a source of food and energy to the nitrogen-fixing organisms. The arrangement of this series was as follows:

1.	200 cc. mineral solution	+ 3 gr. mannite.	Sterile.
2.	" " "	+ 3 gr. fructose.	
3.	" " "	+ 3 gr. mannite.	
4.	" " "	+ 3 gr. calcium lactate.	
5.	" " "	+ 3 gr. lactose.	B.30.
6.	" " "	+ 3 gr. maltose.	
7.	" " "	+ 3 gr. saccharose.	
8.	" " "	+ 3 gr. dextrin.	
9.	" " "	+ 3 gr. mannite.	
10.	" " "	+ 3 gr. calcium lactate.	A. vinelandii.
11.	" " "	+ 3 gr. lactose.	
12.	" " "	+ 3 gr. maltose.	
13.	" " "	+ 3 gr. saccharose.	
14.	" " "	+ 3 gr. dextrin.	
15.	" " "	+ 3 gr. mannite.	
16.	" " "	+ 3 gr. calcium lactate.	
17.	" " "	+ 3 gr. lactose	B. 30 + A. vinelandii.
18.	" " "	+ 3 gr. maltose.	
19.	" " "	+ 3 gr. saccharose.	
20.	" " "	+ 3 gr. dextrin.	

The cultures were analyzed at the end of three weeks, and the following amounts of nitrogen were found:

									Nitrogen Found.	Nitrogen Fixed.
1.	.25 cc	NH_4OH	containing	.0013071	gr. N.	per cc.	=		0.32 mg.	....
2.	.25 "	"	"	"	"	"	=		0.32 "	....
3.	1.55 "	"	"	"	"	"	=		1.97 "	1.65 mg.
4.	.60 "	"	"	"	"	"	=		0.78 "	0.46 "
5.	.20 "	"	"	"	"	"	=		0.26 "	....
6.	23.40 "	"	"	"	"	"	=		30.59 "	....
7.	0.25 "	"	"	"	"	"	=		0.32 "	....
8.	Lost "	"	"	"	"	"	=		...... "	....
9.	10.90 "	"	"	"	"	"	=		14.25 "	13.93 "
10.	0.45 "	"	"	"	"	"	=		0.59 "	0.27 "
11.	0.25 "	"	"	"	"	"	=		0.32 "	....
12.	23.40 "	"	"	"	"	"	=		30.59 "	....
13.	13.20 "	"	"	"	"	"	=		17.25 "	16.93 "
14.	1.85 "	"	"	"	"	"	=		2.42 "	1.06 "
15.	10.00 "	"	"	"	"	"	=		13.07 "	12.75 "
16.	5.50 "	"	"	"	"	"	=		7.19 "	6.87 "
17.	0.30 "	"	"	"	"	"	=		0.39 "	....
18.	23.20 "	"	"	"	"	"	=		30.32 "	....
19.	13.05 "	"	"	"	"	"	=		17.06 "	16.74 "
20.	2.20 "	"	"	"	"	"	=		2.87 "	1.51 "

The analysis of separate portions of maltose and of dextrin showed that the former contained practically as much nitrogen as was found at the end of the experiment, so that there was no appreciable fixation in the maltose solutions. The blank determinations for dextrin showed in the solutions an initial content of 1.36 mg. of nitrogen. Comparing the analytical results for the entire series, we find that B. 30 fixed 1.65 mg. of nitrogen in the mannite solution and .46 mg. in the calcium lactate solution. In the other solutions there was no gain of nitrogen, with the possible exception of dextrin, which foamed over during digestion, and the determination was therefore lost. With A. vinelandii there was a fixation of 13.93 mg. in the mannite solution, 0.27 mg. in the calcium lactate solution, 16.93 mg. in the saccharose solution, and 1.06 mg. in the dextrin solution. Lactose and maltose were not available as a source of food and energy.

Where A. vinelandii and B. 30 were inoculated together, the relations were similar. The yield of combined nitrogen in the mannite and saccharose solutions was not greater—in fact, somewhat less—than in the corresponding solutions inoculated with A. vinelandii alone.

In the case of calcium lactate, on the other hand, the increase over the single inoculations was very marked, and namely, from a fraction of one milligram to 6.87 milligrams. Lactose and maltose proved unsuitable as a source of energy.

Series XX.g.

In this, as in Series XX.c, sodium malate was employed as the source of energy, and the main purpose of this series was to check the results obtained in Series XX.c. The conditions of growth were somewhat different here, however, for the inoculated solutions were kept at a much lower room temperature, probably not averaging more than 15° C., and hence the growth was comparatively slight. The arrangement in this series was as follows:

1.	100 cc.	1 %	malate	solution.	Sterile.
2.	"	2 "	"	"	
3.	"	1 "	"	"	B. 30.
4.	"	2 "	"	"	
5.	"	1 "	"	"	A. vinelandii.
6.	"	2 "	"	"	
7.	"	1 "	"	"	A. vinelandii + B. 30.
8.	"	2 "	"	"	

At the end of three weeks the several solutions were analyzed, and the following quantities of nitrogen were found:

	Nitrogen Found.	Nitrogen Fixed.
1. 0.15 cc. NH_4 OH containing .001366 gr. N. per cc.	= 0.20 mg.	....
2. 0.20 " " " " " "	= 0.27 "	....
3. 1.30 " " " " " "	= 1.77 "	1.57 mg.
4. 0.15 " " " " " "	= 0.20 "	....
5. 0.15 " " " " " "	= 0.20 "	....
6. 0.20 " " " " " "	= 0.27 "	....
7. 1.40 " " " " " "	= 1.91 "	1.71 mg.
8. 0.30 " " " " " "	= 0.41 "	0.21 "

Under the conditions of the experiment, B. 30 fixed 1.57 mg. of nitrogen in the 1 per cent. sodium malate solution, and made no growth at all in the 2 per cent. sodium malate solution. A vinelandii failed to make any growth at all, and when used in combina-

tion with B. 30 it increased the growth of the latter to a very slight extent. It should be remembered, however, that B. 30 can grow at much lower room temperatures than A. vinelandii, and under the given conditions the latter could make the growth that it showed itself capable of making in Series XX.c. At the same time, this series proves conclusively that B. 30 can fix very considerable quantities of atmospheric nitrogen when growing in 1 per cent. solutions of sodium malate.

Series XX.h.

This series was intended to demonstrate whether certain denitrifying bacteria are capable of stimulating the fixation of atmospheric nitrogen by A. vinelandii. The arrangement of this series was as follows:

1.	200 cc. mannite solution.	Sterile.
2.	" " "	Sterile.
3.	" " "	A. vinelandii.
4.	" " "	A. vinelandii + B. 30.
5.	" " "	A. vinelandii + B. New Jersey.
6.	" " "	A. vinelandii + B. 21.
7.	" " "	A. vinelandii + B. 20.
8.	" " "	A. vinelandii + B. 20 + B. 21.
9.	" " "	A. vinelandii + B. megaterium.

Like Series XX.f, the solutions in this series were kept at low room temperatures, which accounts for the comparatively slight fixation by A. vinelandii and A. vinelandii in symbiosis with B. 30. This series was analyzed three weeks after inoculation, and the following results were obtained:

		Nitrogen Found.	Nitrogen Fixed.
1.	0.15 cc. NH_4OH containing .001366 gr. N. per cc.	= 0.20 mag.	....
2.	0.15 " " " " " "	= 0.20 "	....
3.	2.30 " " " " " "	= 3.14 "	2.96 mg.
4.	7.15 " " " " " "	= 9.67 "	9.47 "
5.	2.20 " " " " " "	= 3.00 "	2.80 "
6.	2.05 " " " " " "	= 2.80 "	2.60 "
7.	2.15 " " " " " "	= 2.94 "	2.74 "
8.	2.00 " " " " " "	= 2.73 "	2.53 "
9.	2.20 " " " " " "	= 3.00 "	2.80 "

It appears from the above results that B. 30 increased the fixation by A. vinelandii almost three-fold, but that the denitrifying bacteria diminished, if anything, the yield of combined nitrogen by A. vinelandii. The latter phenomenon was probably due to the liberation of a part of the nitrogen that had already been made to enter into combination by A. vinelandii.

Microscopical examinations showed in 2 and 3 a comparatively few A. vinelandii organisms of abnormal shape and size. Some of them showed slight motility. In 7 and 8, B. 30 were very numerous, while A. vinelandii were few and also abnormal in appearance.

The analysis of these cultures gave the following results.

	Nitrogen Found.	Nitrogen Lost.
1. 18.45 cc. $NH_4OH \times .003020$	= 55.72 mg.	....
2. 18.35 " " × "	= 55.42 "	....
3. 18.20 " " × "	= 54.96 "	.61 mg.
4. 18.20 " " × "	= 54.96 "	.61 "
5. 17.75 " " × "	= 53.60 "	1.97 "
6. 17.80 " " × "	= 53.76 "	1.81 "
7. 18.30 " " × "	= 55.27 "	....
8. 18.35 " " × "	= 55.42 "	....

The analyses indicate that there was a slight loss from 4 and 5, inoculated with A. vinelandii. These losses, while somewhat beyond the limit of error, are still very slight. The losses are greater in 5 and 6, inoculated with B. 30. The growth of this organism in nitrogen-rich media is thus accompanied by small losses of nitrogen. It is strange, however, that in 7 and 8, where the two were inoculated together, there was practically no loss of nitrogen, notwithstanding that growth here was more vigorous than in any of the other cultures.

Miscellaneous Cultures.

Series XXI.

Among the organisms which appeared on the mannite-agar plate was a yeast, which seemed to develop vigorously on this nitrogen-poor medium. Inoculation of this alone, and of the yeast, together with B. pyocyaneus, were made into mannite and glucose solutions, according to the following scheme:

1.	Mannite solution + 1 gr. of soil.		Yeast.
2.	"	" " " "	B. pyocyaneus.
3.	"	" " " "	Yeast + B. pyocyaneus.
4.	Glucose	" " " "	Yeast.
5.	"	" " " "	B. pyocyaneus.
6.	"	" " " "	Yeast + B. pyocyaneus.

The analysis at the end of two weeks gave the following results:

	Nitrogen Found.	Nitrogen Fixed.
1. .70 cc. $NH_4OH \times .002954$	= 2.07 mg.	....
2. .80 " " × "	= 2.36 "	0.29 mg.
3. .75 " " × "	= 2.21 "	0.14 "
4. .75 " " × "	= 2.21 "	....
5. .85 " " × "	= 2.50 "	0.29 "
6. .80 " " × "	= 2.36 "	0.14 "

Blank determinations gave .70 cc. for the mannite solution, and .75 cc. for the glucose solution. The results indicate, therefore, that B. pyocyaneus fixed very slight quantities of nitrogen; quantities not much beyond the experimental error. Since, however, this organism has given repeatedly similar results in other experiments, there is ample justification for the belief that slight quantities of nitrogen may be fixed by B. pyocyaneus under certain circumstances. As to the yeast, inoculated either alone or with B. pyocyaneus, it seemed incapable of fixing free atmospheric nitrogen.

Series XXII.

When the yeast used in Series XXI. was inoculated with B. 32, no nitrogen was found to be fixed by the former. The arrangement of the experiment was as follows:

1.	100 cc. glucose solution.	Sterile.
2.	" " "	Yeast.
3.	" " "	B. 32.
4.	" " "	Yeast + B. 32.

Each flask received also 1 gr. of $CaCO_3$. The solutions were analyzed at the end of two weeks, and the following results were obtained:

	Nitrogen Found.	Nitrogen Fixed.
1. .25 cc. $NH_4OH \times .002954 =$	.74 mg.	....
2. .25 " " $\times$ " =	.74 "	....
3. 1.40 " " $\times$ " =	4.13 "	3.39 mg.
4. 1.25 " " $\times$ " =	3.69 "	2.95 "

In 2, where the yeast alone was inoculated, there was no increase over the sterile solutions. Where B. 32 alone was inoculated there was a fixation of 3.39 mg. of nitrogen, and where the two were inoculated together, 2.95 mg. of nitrogen were fixed, a quantity somewhat less than that fixed by B. 32 alone.

These results showed that B. 32 has a pronounced nitrogen-fixing power. However, continued cultivation in artificial media diminished this power until it was practically lost, as will be seen from the following experiment:

Series XXIII.

1.	200 cc. glucose solution.	Sterile.
2.	" " "	"
3.	" " "	B. 32.
4.	" " "	"
5.	" " "	"

There was also added in each flask 1 gr. of $CaCO_3$. At the end of eight days there was apparently considerable growth in all of the inoculated flasks. When analyzed according to Kjeldahl, the following amounts of nitrogen were found:

	Nitrogen Found.	Nitrogen Fixed.
1. .25 cc. $NH_4OH \times .002943 =$	.74 mg.	....
2. .25 " " $\times$ " =	.74 "	....
3. .45 " " $\times$ " =	1 32 "	.58 mg.
4. .40 " " $\times$ " =	1.18 "	.44 "
5. .50 " " $\times$ " =	1.47 "	.73 "

It will be seen from the above that the nitrogen-fixing power of B. 32 was reduced considerably. Repeated inoculations into fresh glucose solution gave similar results, and in some cases there was practically no nitrogen fixed. This experience is in accord with that of other investigators. Thus Beijerinck noted something similar in the

case of B. mesentericus vulgatus, as was already noted in the first part of this paper. Professor Chester, of the Delaware Experiment Station, has also found something similar in the case of an organism isolated by him from a Delaware soil, as was stated by him in a private communication to the writer.

REPORT OF THE HORTICULTURIST.

REPORT OF HORTICULTURIST.

The horticultural work of the Station, covering, as it does, permanent experimental plots, changes very little from year to year. The detail work of record-taking has increased very materially as the various fruits have matured and produced crops.

The first table, No. 1, contains the rainfall records for the year ending October 31st, together with normal for this section given by the State Weather Service. Our records have not as yet covered a sufficient period for determining a normal for this Station. Table 2 gives the monthly and yearly records for the past eight years. The normal rainfall for months and year and the averages of our records are given for comparison.

The early part of the past season was marked by a severe drought, covering seven and one-half weeks, from April 16th to June 7th. Precipitation was recorded during this time on four days only, with a total of only .29 inches. Irrigation is a necessity during such times.

Excessive moisture marked most of the remainder of the season. June and October had practically double the normal rainfall; August a fifth more than the normal, while July and September had the normal precipitation.

September 16th a severe wind-storm visited this section, doing considerable damage to trees and blowing off the greater part of late apples and pears.

October 9th gave a record-breaking rainfall of 5.28 inches in twenty-four hours. The highest previous rainfall in our records was one of 3.40 inches, on July 7th, 1901.

TABLE 1.

Showing Daily and Monthly Precipitation in Inches at the College Farm for the Year Ending October 31st, 1903.

DATE.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.
1		0.44		T							0 01	
2												
3		0.79	1.14			0.03						0.25
4				1.09		0.71	0.18		0.11	0.25		
5		0.53		0.26	T					1.94	0.10	
6	0.03		0.20						0.08		0.01	0.01
7	0.05	0.06	0.01		T	0.26		0.42		0.21		0.01
8				0.33	0.84	0.55		0.06			0.02	0.46
9					1.31	0.15		0.46		0.19		5.28
10								0.17				0.22
11		0.08	0.74	0.26	0.25		T	0.03	0.23	0.64	0.04	0.24
12	0.07	0.14	0.11	0.17		0.19		2.52	0.04			0.03
13		0.57						0.06	0.16			0.01
14		0.07				1.70		0.38		0.24		
15				0.15		0.91		0.09	0.03			
16		1.42		0.48		0.07		0.18		0.01	2.02	
17		0.48		0.95				0.04		T	0.92	0.37
18								0.30	1.84		0.03	0.19
19								0.35	0.15	0.05		
20								0.37	0.03	0.03		
21		0.61	0.57		0.11			0.20	0.08			
22		0.85			0.63		0.06		0.65			
23	0.05				0.89			0.67	0.78			0.06
24					0.02		0.04	0.29		0.01		0.03
25		0.24	0.60									
26	1.09									0.13		
27	0.02										0.05	
28			0.40	0.92			T			1.35	0.49	
29		0.45	0.01					0.74		0.71		
30	0.27	0.10	0.06		0.22			0.02	0.03	0.18		
31					0.47		0.01		0.86	0.03		
Total	1.58	6.83	3.84	4.61	4.74	4.57	0.29	7.35	5.07	5.97	3.69	7.16
Normal	3.74	3.66	3.82	3.64	3.77	3.68	4.02	3 80	4.92	4.93	3 94	3.45

TABLE 2.

Showing Monthly Precipitation in Inches Since January 1st, 1896.

YEAR.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	Yearly total.
1896	....	....	1.68	5.85	5.92	1.41	3.70	4.93	4.37	2.42	4.81	1.62	*36.71
1897	2.95	1.59	2.39	2.77	2.47	3.47	6.45	2.50	12.84	3.81	2.10	1.59	44.93
1898	4.52	5.09	3.92	3.49	3.09	4.17	7.86	1.13	3.91	6.44	1.46	5.30	50.88
1899	7.14	3.16	4.88	5.37	6.63	1.50	2.04	3.54	6.32	3.45	7.80	2.96	54.79
1900	4.11	2.06	4.35	5.30	3.40	2.38	5.58	2.64	6.94	2.24	3.30	3.53	45.83
1901	4.27	2.32	2.01	0.76	5.19	7.39	5.01	0.81	9.12	8.90	1.86	1.99	49.63
1902	2.21	7.30	2.70	6.46	3.79	3.09	1.51	6.08	3.42	6.29	5.25	7.76	55.86
1903	1.58	6.83	3.84	4.61	4.74	4.57	0.29	7.35	5.07	5.97	3.69	7.16	55.70
Average	3.83	4.05	3.22	4.31	4.40	3.50	4.06	3.62	6.50	4.94	3.78	4.05	†51.09
Normal as given for this section	3.74	3.66	3.82	3.64	3.77	3.68	4.02	3.80	4.92	4.93	3.94	3.45	47.87

* Ten months only.

† 1897 to 1903, inclusive.

The Permanent Experiment Plots.

ASPARAGUS AND SMALL FRUITS.

The general plan is outlined. In each case, currants and gooseberries excepted, six varieties or six rows, 160 feet long, and set in one block, are duplicated, giving twelve rows; of which rows 1 and 7, 2 and 8, &c., are the same variety. Rows 7 to 12, inclusive, are irrigated as needed, while rows 1 to 6 are never irrigated. Lengthwise each block is divided into four equal parts or plots forty feet long. Those unirrigated are numbered 1 to 4, those irrigated 5 to 8. Plots 1 and 5, 2 and 6, are treated identically, except that plots 5 to 8 are irrigated. The plan for currants and gooseberries is the same, excepting that there are only four varieties instead of six, with six plots twenty-five feet long, instead of eight. Table 3 shows in detail the fertilizers or manures to be applied to the various plots, with the times for application, and has been carefully adhered to the past season. Water was applied to the irrigated plots during May and the first part of June, as noted in each case.

The general arrangement of plots and fertilizers, &c., allows a study of—

a. The effect of irrigation.

b. The relative effect of manures and fertilizers with and without irrigation:

1. Upon early yield.
2. Upon total yields.

c. The effect of the addition of nitrate of soda.

ASPARAGUS.

A change in method of cutting asparagus was made this year to better meet the needs or demands of the local market. Our practice has been to ridge the rows and cut the asparagus stalk just as it comes through the ground, giving a bleached stalk. This year the rows were not ridged and cutting was delayed until the stalk was four to six inches out of the ground, giving green asparagus that better meets the demand in the local market than the bleached.

The plantation was cultivated March 25th, and on the 30th the first cutting was made. The earliest cutting in other seasons was April 23d, 1902. No local asparagus was in market at that time.

TABLE 3.

Showing Fertilizers, Amounts and Time Applied to the Different Plots, Asparagus and Small Fruits.

KIND OF FRUIT OR VEGETABLE.	Plots 1 and 5.	Plots 2 and 6.	Plots 3 and 7.	Plots 4 and 8.
Asparagus.....	20 ts. *yard manure applied in fall.	1000 lbs. complete† applied in spring.	1000 lbs. complete applied in spring; 300 lbs. bone and potash‡ applied in fall.	1000 lbs. complete applied in spring; 300 lbs. bone and potash applied in fall; 200 lbs. nitrate soda applied when cutting ended.
Blackberries.	20 ts. yard manure applied in fall.	500 lbs. complete applied in spring.	500 lbs. complete applied in spring; 300 lbs. bone and potash applied in fall.	500 lbs. complete applied in spring; 300 lbs. bone and potash applied in fall; 200 lbs. nitrate soda applied after blossoming.
Raspberries..	20 ts. yard manure applied in fall.	500 lbs. complete applied in spring.	500 lbs. complete applied in spring; 300 lbs. bone and potash applied in fall.	500 lbs. complete applied in spring; 300 lbs. bone and potash applied in fall; 200 lbs. nitrate soda applied after blossoming.
Strawberries..	500 lbs. complete applied in spring.	500 lbs. complete applied in spring; 150 lbs. nitrate soda applied after blossoming.	500 lbs. B., P. and A. P.§ applied in spring; 150 lbs. nitrate soda applied after blossoming.	500 lbs. B., P. and A. P. applied in spring.
	Plots 1 and 4.	Plots 2 and 5.	Plots 3 and 6.	
Currants..	20 ts. yard manure applied in fall.	500 lbs. B., P. and A. P. applied in fall.	500 lbs. B., P. and A. P. applied in fall; 150 lbs. nitrate soda applied after blossoming.	
Gooseberries..	20 ts. yard manure applied in fall.	500 lbs. B., P. and A. P. applied in fall.	500 lbs. B., P. and A. P. applied in fall; 150 lbs. nitrate soda applied after blossoming.	

* The quantities of manure or fertilizer given are in every case the amounts per acre to be applied.

† Complete Fertilizer—a mixture of the best forms of fertilizing constituents, analyzing nitrogen, 4.5 per cent.; phosphoric acid (available), 7.7 per cent., and potash, 13.3 per cent.

‡ An even mixture of ground bone and muriate of potash.

§ An even mixture of ground bone, muriate of potash and acid phosphate.

Had there been, leading grocers said the price would have been at least twenty-five cents per bunch. Cutting was continued until June 19th, making the thirtieth for the season. Twelve cents per bunch was the lowest price quoted. Detailed records of the plantation for 1903 and all previous seasons and averages of the same are given in Table 4.

A comparison of varieties shows that the Elmira leads in early yields, with Barr's Mammoth a very close second. Palmetto stands third in order. In total yields, however, Palmetto leads. Of the eight plots, Palmetto stands first on six and second on two plots. Grouping the yields of each variety from all plots, Palmetto exceeds Elmira, its nearest competitor, by almost 36 per cent. Calculating the yields to the basis of an acre, the early and total yields for the season are as follows:

	1903. Yield per Acre. Early.	Total.
Barr's Mammoth	353.1 lbs.	4,298.1 lbs.
Donald's Elmira	354.8 "	5,241.7 "
Columbian Mammoth White	337.8 "	5,006.0 "
Palmetto	344.6 "	7,123.6 "
Conover's Colossal	292.7 "	4,698.9 "
Giant Brunswick	240.8 "	4,360.3 "
Moore's Cross-Bred	245.0 "	3,765.5 "
Giant Argenteuil	*279.0 "	2,765.0 "

The wholesale price of asparagus in the local market averaged 21.7 cents per bunch of one pound for the early cut, and 13.1 cents for the crop. Allowing 10 per cent. for waste, &c., in bunching, the market value of early and total yields of Palmetto and Elmira, the two varieties having the largest yields, are in order, $67.29 and $69.29, and $839.87 and $617.99 per acre.

* Third year's cut.

TABLE 4.

Asparagus—Fertilizer Plots.

VARIETY.	UNIRRIGATED.											
	PLOT 1.			PLOT 2.			PLOT 3.			PLOT 4.		
	First three cuttings.	Total cut.	Tops.	First three cuttings	Total cut.	Tops	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.
	oz.	oz.	lbs.	oz.	oz.	lbs.	oz	oz.	lbs.	oz.	oz.	lbs.
Barr's Mammoth...	42.5	412.0	19.00	39.5	400.5	19.50	23.0	225.5	14.00	29.0	307.5	22.25
Donald's Elmira ...	55.0	487·5	25.50	30.5	394.0	20.00	24.5	478.0	25.00	24.0	343.5	16.50
Columbian Mammoth White........	29.5	482.0	26.00	22.5	399.0	21.00	17.5	303.0	19.00	15.0	285.0	19.00
Palmetto	28.0	626.5	31.00	23.5	541.0	25.00	11.5	471.5	29.50	25.0	486.0	31.50
Conover's Colossal..	33.0	474.5	19.50	14.0	303.5	15.50	17.0	258.5	18.00	19.5	287.5	19.50
Giant Brunswick...	22.5	440.5	26.50	19.5	379.0	18.00	12.0	243.0	14.75	10.0	293.5	33.25
Total................	210.5	2923.0	147.50	149.5	2417.0	119.00	105.5	1979.5	120.25	122.5	2003.0	142.00
Totals in 1898...	68.0	238.5	156.00	95.5	234.5	113.50	76.5	176.5	108.00	67.0	153.0	61.00
Totals in 1899...	136.0	697.0	109.50	148.0	620.0	76.50	130.0	537.5	76.00	98.0	420.0	71.50
Totals in 1900...	149.5	1786.5	176.00	229.0	1540.5	118.00	182.0	1389.0	102.00	149.0	1224.0	95.00
Totals in 1901...	63.5	2039.0	242.25	133.0	1645.5	198.75	90.0	1426.5	155.25	71.0	1288.0	157.75
Totals in 1902...	180.0	2881.5	131.50	126.0	2407.0	88.25	70.0	1953.0	70.75	70.5	1961.0	73.50
Average, six crops..	134.6	1760.9	160.46	146.8	1477.4	119.00	109.0	1243.7	105.38	96.3	1174.8	100.13

Asparagus—Fertilizer Plots.

VARIETY.	IRRIGATED.											
	PLOT 5.			PLOT 6.			PLOT 7.			PLOT 8.		
	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.
	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.
Barr's Mammoth...	32.5	401.0	16.00	8.0	264.0	11.00	15.0	270.0	22.75	18.0	245.5	17.00
Donald's Elmira.....	32.0	421.5	20.00	19.0	383.0	21.00	13.0	255.0	19.50	10.5	318.0	27.00
Columbian Mammoth White........	27.5	459.5	25.00	45.5	416.0	24.00	24.5	322.5	20.00	16.5	275.0	30.50
Palmetto	18.5	445.0	23.00	35.5	595.0	28.50	36.5	556.5	28.50	24.0	465.0	35.00
Conover's Colossal..	30.0	384.5	23.00	22.5	416.0	27.25	20.5	344.5	23.00	15.5	292.5	21.25
Giant Brunswick...	13.0	264.5	30.00	25.5	354.5	32.50	16.5	343.5	32.50	22.5	244.0	15.75
Total	153.5	2376.0	137.00	156.0	2428.5	144.25	126.0	2092.0	146.25	107 0	1840.0	146.50
Totals in 1898...	72.5	224.5	137.50	100.0	238.5	111.50	84.5	196.5	108.50	77.5	164.5	81.00
Totals in 1899...	135.0	666.0	116.50	180.0	658.5	87.00	136.5	589.5	77.00	101.5	490.5	66.50
Totals in 1900...	109.5	1590.5	176.50	206.5	1544.5	136.50	200.0	1447.0	117.00	151.5	1199.0	105.00
Totals in 1901...	56.5	1770.5	282.50	83.0	1806.5	183.50	75.5	1488.5	153.25	58.5	1349.5	191.25
Totals in 1902...	114.0	2420.0	131.00	111.0	2462.0	92.25	86.5	2033.5	88.25	77.5	1943.0	84.50
Average, six crops..	106.8	1507.9	155.17	139.4	1523.1	125.83	118.2	1307.8	115.04	95.6	1161.4	112.46

.Elmira has a market value of early yield slightly larger than Palmetto, but in total yields the value of Palmetto exceeds that of Elmira by $221.88 per acre.

Considering the results by plots, all varieties together, we have:

a. An increase in plots 6 and 7 over their unirrigated duplicates in both early and total yields. Plots 1 and 4, unirrigated, exceed in yield their irrigated duplicates in both early and total cut. Taking, however, the four plots in each case together, those unirrigated have a yield of 8 per cent. in early and 7 per cent. in total cut, larger than that obtained upon the irrigated plots.

In the averages of the six crops, an increase occurs in early yield on one plot and in total yield on two plots, *i. e.,* 6 and 7. Taken together, however, the irrigated plots are exceeded in yield by those not irrigated by 6 per cent. in early, and nearly 3 per cent. in total yields.

The growth of tops in both the season of 1903 and the average of the six years has been larger on the irrigated plots, 6, 7 and 8, than on their unirrigated duplicates. Grouping the plots, those irrigated have given a growth of tops of 8 per cent. and 5 per cent., respectively, more than those unirrigated.

b. Plot 1, unirrigated—manure—and plot 6, irrigated—complete fertilizer only—have given the largest yields in both the early and total cut. Plot 5, irrigated—manure—and plot 2, unirrigated—complete fertilizer only—are second in order in both early and total yields. Averaging the six crops, however, the complete fertilizer only, on plots 2 and 6, have given the largest early yields with 1 second, where not irrigated and 7 second, under irrigation.

In the average total yields, manure leads, with the complete fertilizer only, second in order where not irrigated. Under irrigation the order is reversed. The manure plots continue to give much larger growth of tops than obtained on any other plots. Plot 4, with nitrate of soda, and not irrigated, stands third in order of yield in both the early and total cuts. Plot 8, the duplicate, where irrigated, is the lowest in yields in both cases.

In the averages of the six crops, plots 4 and 8 are lowest in yields.

The records for 1903, as well as the six-year average of the two newer varieties, and the two varieties set with selected crowns, are found in Table 5.

The use of selected crowns is not to be recommended, except in special cases, and for immediate effect. For the last three seasons the yields of the two rows so set have not exceeded the yields of rows set with the ordinary crowns sent out by the nurseries.

Moore's Cross-bred has not proved as productive as the other well-known sorts. Giant Argenteuil has only been in cutting three years, and is, therefore, not comparable with the other sorts in yields. It seems to be a very desirable sort, however, and we believe a productive one.

The results by plots are practically identical with that of the unirrigated block already discussed, or in order as the plots are numbered plots 1, 2, 3 and 4. Exceptions are in early yield of 1903, when plot 2 leads and with plot 4 lowest, instead of third in order, in both early and total cut.

TABLE 5.

Asparagus—New Varieties and Selected Crowns.

VARIETY.	PLOT 1.			PLOT 2.			PLOT 3.			PLOT 4.		
	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.	First three cuttings.	Total cut.	Tops.
	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.	oz.	oz.	lbs.
Donald's Elmira....	29.5	483.5	26.00	28.0	410.5	23.50	21.0	276.0	16.00	21.5	249.5	19.00
Palmetto..............	54.5	594.5	29.50	37.0	455.5	23.00	24.0	499.5	31.00	18.0	358.0	28.50
Moore's Cross-bred..	11.0	336.5	17.00	27.0	367.5	15.00	21.5	265.0	18.50	12.5	274.5	19.00
Giant Argenteuil....	2.0	135.0	15.00	27.5	199.0	14.00	25.0	190.5	18.25	27.5	288.0	32.00
Total	97.0	1549.5	87.50	119.5	1432.5	75.50	91.5	1231.0	83.75	79.5	1170.0	98.50
Totals in 1898..	64.5	152.0	95.00	40.0	117.5	61.50	57.5	140.5	86.00	49.0	119.0	63.50
Totals in 1899...	97.0	425.5	59.00	77.5	357.5	49.50	64.0	341.5	47.50	43.5	277.5	45.00
Totals in 1900...	102.0	956.0	95.50	78.5	805.5	94.00	81.5	732.5	93.00	71.5	579.0	72.00
Totals in 1901...	27.5	920.0	120.75	53.5	865.0	121.75	58.0	820.0	120.00	28.0	804.0	130.00
Totals in 1902...	52.5	1447.5	79.75	60.0	1314.5	65.00	56.5	1277.5	65.00	40.0	1189.0	66.00
Average, six crops..	73.4	908.4	89.58	71.5	815.4	77.88	68.2	757.2	82.54	51.9	689.8	79.17

A RESUME.

A history of the plantation and the general results to date seem desirable at this time.

The soil available for the plantation was not the most suitable for the purpose. It is a gravelly clay loam, slopes gently to the south, and is underlaid with a gravelly subsoil. Where choice is possible, particularly for commercial purposes, a sandy soil is better adapted to the needs and character of this vegetable. For home use, however, good results may be had from almost any soil that is not too stiff and heavy.

The plan outlined called for sixteen rows, each 175 feet long, divided crosswise into four equal parts or plots of forty feet each, separated by paths five feet wide, and calling for four methods of manuring and fertilizing, as follows:

Plot 1. Manure, 20 tons per acre, applied when setting and thereafter in fall or early winter.

" 2. A complete fertilizer. A mixture of the best forms of fertilizing constituents, analyzing nitrogen 4.5 per cent., phosphoric acid (available), 7.7 and potash 13 3 per cent., applied at the rate of 500 pounds per acre in the spring.

" 3. The same fertilizer used on plot 2, applied at the same rate and time, with a mixture of equal parts of ground bone and muriate of potash, applied at the rate of 300 pounds per acre in the fall.

" 4. The same mixtures, applied at the same rate and times as used on plot 3, with nitrate of soda applied at rate of 200 pounds per acre about the first of July or at end of the cutting season.

The varieties used included practically all that were then offered for sale, and were as follows:

Barr's Mammoth,	Conover's Colossal,
Donald's Elmira,	Giant Brunswick,
Columbian Mammoth White,	Moore's Cross-bred.
Palmetto,	Giant Argenteuil.

With two or three exceptions, two-year-old roots were purchased. The one-year roots were fully as satisfactory, and where good ones can be obtained, are to be preferred. Neither roots nor seed of the Giant Argenteuil were then obtainable, and to secure this variety seed was imported for the Station during 1896, and sown early the following spring.

A comparison seemed desirable of large, strong, selected crowns, and sufficient for two rows were purchased of a grower. These roots would average nearly, or quite, double the size of the general run of the other roots purchased.

The plantation was set in the spring of 1896. After thoroughly working the soil—previously fall-plowed and subsoiled—double furrows were turned five feet apart, the object being to get the roots about five inches below the surface of the soil. Where sufficient depth was not secured with the plow, the spade was used.

In setting the roots, one-half the fertilizer was strewn in the bottom of the furrow, and stirred or mixed into the soil by means of a small hand-plow. Manure was also applied on plot 1 at time of setting the roots. In this plot the furrows were made deeper and one-half the manure put in and covered with two inches of soil before setting the roots. The remaining half of the manure and fertilizer was strewn along the rows later, or after the roots had started to grow. The roots were placed approximately thirty inches apart in the rows.

Good cultivation has been given each season. Before growth started each spring, the land has been thoroughly worked and pulverized with disk and Acme harrows, and then the row uncovered slightly by using a single cultivator with shovels set to throw dirt outward. After growth started, single cultivators have been used entirely and were run over the ground every ten days, quite regularly.

In preparation for cutting, the practice has been until the past year to throw a ridge of soil over the row as soon as growth started and to cut as soon as the shoot showed through this ridge, which had a depth sufficient to allow a length of six to seven inches to the cut shoot. This method has given the bleached asparagus. Our local market has been demanding green asparagus, hence this past year instead of ridging as formerly, the crowns were covered with only about three inches of soil and shoots only cut as they attained a height of four or five inches, cutting an inch or so under surface of soil.

The first cutting from the plantation was made in 1898, the third season after setting.

Care was exercised not to cut sufficient to weaken the vitality of the plant. The records show that nine cuttings were made, extending from April 26th to June 1st.

The second year, some twenty-two cuttings were made, the third, twenty-four and annually since about thirty cuttings have been taken from the plantation.

Detailed records have appeared each year in the annual report of the Station. In what follows, the average results of the six years of cutting and the crop of 1903 are considered.

The Yield of Different Varieties.

Combining and averaging the yields of all varieties for the six years, and calculating the results to the basis of an acre, we have the following yields in early and total product for the different sorts. The yields given average low, since the first years of cutting are included. The results of the crop of 1903 are included as representing more nearly the results of a matured field. The first three cuttings are taken to represent the early cutting. This is an arbitrary division, but a study of the yearly prices shows that the period represented by the first three cuttings is the period of highest prices, and is, therefore, taken for a comparison of early yields.

TABLE 5a.

Asparagus—Yields of Varieties per Acre.

VARIETY.	AVERAGE OF THE FIRST SIX YEARS OF CUTTING.		YIELD IN 1903. CROP FROM A MATURED FIELD.	
	Early yield.	Total yield.	Early yield.	Total yield.
	lbs.	lbs.	lbs.	lbs.
Barr's Mammoth	271.7	2,713.7	353.1	4,298.1
Donald's Elmira	305.1	3,430.9	354.8	5,241.7
Columbian Mammoth White	293.0	3,071.8	337.8	5,006.0
Palmetto	378.6	4,532.1	344.6	7,123.6
Conover's Colossal	245.5	3,131.0	292.7	4,698.9
Giant Brunswick	117.1	2,110.1	240.8	4,360.3
Moore's Cross-bred	174.7	2,590.4	245.0	3,765.5
Giant Argenteuil	*186.7	*1,621.5	†279.0	†2,765.0
Average	246.6	2,900.2	306.0	4,657.4

* Three years' cutting only. † Third year of cutting.

The question of varieties for setting new plantations is a very important one, as the above figures show. In the averages of the six crops, the yields of the five well-known sorts range from 2,713.7 pounds to 4,532.1 pounds per acre, with an average for the eight varieties of 2,900.2 pounds per acre.

The yields of the crop of 1903 are considerably larger than the average of the six crops, but the percentage of difference between the best and the poorest of the five well-known sorts is practically identical. In both cases there are four varieties exceeding and four yielding less than the average of all varieties.

In the figures given, excepting early yield of 1903, Palmetto is by far the most productive sort. Its productiveness, coupled with its power of resisting diseases, makes the Palmetto one of the most, if not the most, desirable varieties of asparagus. Donald's Elmira is second in order in yield, in both average crop and crop of 1903. It is exceeded in yield, however, by Palmetto by 24 per cent. in early and 32 per cent. in total yields, in the average crop, and by nearly 36 per cent. in total of crop of 1903.

The variety Giant Argenteuil has been in cutting three seasons only. For comparison, the average yields of the first three seasons of the Elmira and Palmetto varieties were calculated and found to be 1,986.1 pounds and 2,552.7 pounds per acre, respectively, as against 1,621.5 pounds given by the Giant Argenteuil.

The Value of Different Varieties.

The comparative value of varieties is still further shown by the cash returns per acre, as given below. With the exception of 1898, yearly records have been kept of the wholesale price of asparagus in the local market. The average of these prices give a value per pound bunch for the early cut of 17.5 cents, and for the total cut of 11.2 cents. Similar figures for the crop of 1903 are 21.7 cents and 13.1 cents, respectively.

The yields given above are the total cut in every case. In calculating cash values per acre, 10 per cent. is allowed for culls and waste in bunching, &c.

It is thus very evident that the cash return to be obtained in asparagus growing depends very much upon the variety. In the average of the six crops taken from the field, Palmetto gives a cash return of $11.56 in early and $111.01 in the total yield, over and above that obtained from the Elmira, the second in order in productiveness and value.

TABLE 5b.

Asparagus—Varieties—Value per Acre.

VARIETY.	AVERAGE OF THE FIRST SIX YEARS OF CUTTING.		CROP OF 1903. RETURNS FROM A MATURED FIELD.	
	Early, 17.5c. per bunch.	Total, 11.2c. per bunch.	Early, 21.7c. per bunch.	Total, 13.1c. per bunch.
Barr's Mammoth	$42 79	$273.54	$68.96	$506.75
Donald's Elmira	48.06	345.83	69.29	617.99
Columbian Mammoth White	46.15	309.64	65.97	590.21
Palmetto	59.62	456.84	67.29	839.87
Conover's Colossal	38.66	315.60	57.16	554.00
Giant Brunswick	18.45	212.70	47.02	514.08
Moore's Cross-bred	27.51	261.12	47.85	443.95
Giant Argenteuil	*29.40	*163.44	†54.49	†325.99
Average	$38.83	$292.34	$59.75	$549.11

* Three years' cutting only. † Third year of cutting.

In the crop of 1903, the differences in total yields and value are considerably larger than in the average crop, and in favor of the variety, Palmetto. The total return is $839.87, with an excess over the value of Elmira of $221.88. Barr's Mammoth gave the lowest cash return of the five well-known varieties, both in the average of the five crops and that of 1903. The cash value of total yield of Palmetto exceeds that of Barr's Mammoth by $183.30 and $333.12, or by 67 per cent. and nearly 66 per cent., respectively.

The use of selected crowns cannot be recommended as a profitable course to pursue. The care received after setting seems to have more to do with the success and productiveness of the plantation than the use of selected crowns. During the first two seasons the growth of tops from the selected crowns averaged over 33 per cent. larger than that from other rows. When cutting commenced in the third year, the selected crowns of Palmetto gave an increase of 4 per cent., while the yield of the Elmira selected roots was less than that obtained from the other rows. In succeeding years, with few exceptions, the yields from the rows of selected roots have not exceeded that obtained from the other rows.

Fertilizers, Cost, Etc.

The general plan outlined of fertilizing and manuring has been closely followed throughout. In the summer of 1898 an extra application of manure and complete fertilizer was applied upon the same plots and at the same rate as given in the plan. In the spring of 1903 the application of complete fertilizer to plots 2, 3 and 4, was doubled, or applying it at the rate of 1,000 pounds per acre. In Table 6 are given the amounts of manure and fertilizer used at each application, the total applied, and the total and average annual cost per plot for the six producing years.

TABLE 6.

Asparagus—Amount and Cost of Fertilizers Applied.

PLOT AND KIND OF FERTILIZER.	Amount applied each time.	Total amount applied to date.	Cost per ton.	Total cost per plot.	Average annual cost for the six years of cutting.
	lbs.	lbs.			
Plot 1.—Manure	2,963.0	26,667.0	$1 50	$20 00	$3 33
Plot 2.—Complete	37.0	370.0	30 80	5 70	95
Plot 3.—Complete	37.0	370.0	30 80	5 70	1 39
Bone and potash	22.2	155.4	34 00	2 64	
Plot 4.—Complete	37.0	370.0	30 80	5 70	1 83
Bone and potash	22.2	155.4	34 00	2 64	
Nitrate of soda	14.8	118.4	45 00	2 66	

Manure was charged at the rate of $1.50 per ton, and the figures in the last column of table show that the annual cost for manure—$3.33—was the highest of any of the four plots. Plot 4 is second, with only $1.83, while plot 2 is lowest with an annual cost of only 95 cents, less than one-third the annual cost of manure.

Yields.

The average early and total yields per plot are given in Table 7, together with the value per plot of its product, with the annual cost of manure and fertilizer, and in the last column under each heading the cash return for each dollar spent for manure or fertilizer.

In this table, no allowance is made for culls or waste. The relations would, however, be the same were a 10 per cent. allowance made.

TABLE 7.

Asparagus—Yields and Returns.

PLOT.	EARLY YIELDS.				TOTAL YIELDS.			
	Total early cut.	Value, 17.5c. per lb.	Annual cost of manure and fertilizer.	Returns per dollar of manure and fertilizer.	Total yield.	Value, 11.2c. per lb.	Annual cost of manure and fertilizer.	Returns per dollar of manure and fertilizer.
	lbs.				lbs.			
Plot 1	20.8	$3.55	$3.33	$1.07	240.1	$26.89	$3.33	$8.08
Plot 2	22.9	4.01	0.95	4.22	244.9	27.43	0.95	28.87
Plot 3	19.0	3.33	1.39	2.40	212.7	23.82	1.39	17.14
Plot 4	15.6	2.73	1.83	1.49	194.7	21.81	1.83	11.92

In total yields from the different plots, plot 2 has given the largest yields and hence largest returns. Plot 4 is lowest in yields. Considering the results upon the cost basis, and returns per dollar of cost, some very significant figures are presented.

Plot 1, receiving manure at an annual cost of $3.33, has given a return of $1.07 in early and $8.08 in total yield.

Plot 2, complete fertilizer only, costing 95 cents per year, has returned per dollar spent $4.22 and $28.87, respectively.

Plot 3, complete fertilizer with bone and potash in the fall added, costing $1.39 yearly, has given in order $2.40 and $17.14 return for each dollar expended in fertilizer.

Plot 4, complete fertilizer with bone and potash, and with the summer application of nitrate of soda, costing $1.83, returns $1.49 and $11.92, respectively.

Cost of production is the stumbling block for many a manufacturer, and the business of farming can be no exception. Manure has had the largest annual cost with the lowest returns for the money spent, while plot 2, complete fertilizer only, costing annually less than one-third that of the manure plot, has given a cash return, per dollar of cost of fertilizer, over three times that on plot 1. At a fair price for manure, on the basis of returns obtained from the use and cost of the complete fertilizer, the former is worth only 42¾ cents per ton.

Plots 3 and 4, while costing annually more than plot 2, have given returns for each dollar spent of double and almost 50 per cent., respectively, more than obtained from the use of manure on plot 1, but only 59 per cent. and 41 per cent., respectively, that obtained from the use of the complete fertilizer alone on plot 2.

Calculating the yields and returns to the acre basis, we have the results given in Table 7a. The first column shows the average annual cost of manure or fertilizer for the first six years of cutting. Under the average of the first six crops is given the early yield, its value, the total yield, value, and value less cost of manure or fertilizer. The total yields of 1903, value and value less average cost of manure or fertilizer, is included for comparison, and as

TABLE 7a.

Asparagus—Yields and Returns per Acre.

PLOT AND KIND OF FERTILIZER.	Average annual cost of manure or fertilizer for six years of cutting.	AVERAGE FIRST SIX CROPS.					CROP OF 1903.		
		Total early cut.	Value, 17.5c. per lb.	Total yield.	Value, 11.2c. per lb.	Value, less cost of manure or fertilizer.	Total yield.	Value, 13.1c. per lb.	Value, less average cost of manure or fertilizer.
		lbs.		lbs.			lbs.		
Plot 1.—Manure	$45.38	249.1	$43.59	2941.7	$329.47	$284.09	5231.3	$685.30	$639.92
Plot 2.—Complete fertilizer	12.93	280.4	49.07	3000.2	336.02	323.09	4807.9	629.83	616.90
Plot 3. {Complete fertilizer, Bone and potash}	18.92	232.8	40.74	2605.4	291.80	272.88	4060.6	531.94	513.02
Plot 4. {Complete fertilizer, Bone and potash, Nitrate of soda}	24.91	191.1	33.44	2384.9	267.11	242.20	3974.9	520.71	495.80

representing the results obtainable from a mature field. From data at hand it is not possible to estimate cost of harvesting. This item would, however, vary as the product varies in the different plots.

On the acre basis, the annual cost of manure is shown to be $45.38, as against $12.93 for the complete fertilizer used upon plot 2, and $18.92 and $24.91, respectively, for mixtures used upon plots 3 and 4.

In the average of the six crops, plot 2, at an annual cost of only 28½ per cent. that of manure, gives a larger yield and return in both early and total product than obtained from the use of manure upon plot 1.

The net value of the yield of plot 2 exceeds that of plot 1 by 13.7 per cent.

In the crop of 1903 the manured plot, No. 1, gives a larger total yield and return than are obtained from plot 2, complete fertilizer. The returns, however, per dollar of cost remain practically the same as previously given.

The relation of yields upon the four plots varies from year to year, but averaging the results of the six seasons' work the complete fertilizer is shown not only to be cheapest in cost, but the most effective in crop production of the four methods of fertilizing used.

Manure has the largest annual cost and stands second only in yields and returns.

The mixtures used upon plots 3 and 4, while costing considerably less and yielding, per dollar of cost, greater returns than obtained from the use of manure, are not, however, as effective in total crop production as the manure upon plot 1, or complete fertilizer only, upon plot 2.

Summary.

1. The selection of varieties in planting is very important. Palmetto, a disease-resisting variety, gives a yield exceeding that of the Elmira, second in order, by 32 per cent., in the average of six crops, and by nearly 36 per cent. in crop of 1903.

2. The cash value by which Palmetto exceeds any other variety, equals $111.01 and $221.88, for the average crop and that of 1903, respectively.

3. The use of selected (crowns) roots, is not recommended. Good one-year-old roots are fully as satisfactory as two-year-old roots. The after care seems to have more influence upon the results obtained than character or age of roots used.

4. Manure at $1.50 per ton, twenty tons per acre, is the most expensive method of supplying plant-food. The returns per dollar of cost are the lowest of any of the four methods of fertilizing used.

5. In the average total yields obtained, irrespective of cost, the manured plot stands second in order.

6. The complete fertilizer alone, applied in the spring upon plot 2, has given the lowest annual cost, less than one-third that of manure; has given the largest total yield, exceeding the yields obtained with manure by 2 per cent., and gives returns per dollar of cost over three and one-half times that returned per dollar of cost where manure was used.

7. The net value of yields obtained when the complete fertilizer alone was used, plot 2, exceeds that obtained by the use of manure, plot 1, by 13.7 per cent.

8. The complete fertilizer alone gives a total average yield 15 per cent. greater and a return per dollar of fertilizer cost, 68 per cent. larger than that given by the mixture used on plot 3, the second plot in order of cost.

9. The addition to the complete fertilizer of bone and potash in the fall, as upon plot 3, and of bone and potash in the fall, and nitrate of soda at the end of the cutting season, as upon plot 4, has resulted in both cases in yields considerably less than that which was obtained by the complete fertilizer only, as used upon plot 2.

10. The total yields obtained upon plots 3 and 4, while costing less and giving returns per dollar of fertilizer cost of double and of 50 per cent. greater, respectively, than that where manure was used, are, however, only 88.5 and 81 per cent., respectively, that given by the manured plot, No. 1.

RASPBERRIES—A RESUME.

At the end of the picking season of 1903, it was decided to renew the raspberry plantation, because of some irregularities in the stand and undesirable varieties and to present the results obtained to date in the year's report.

The original plan called for six standard varieties—three red, one yellow and two black cap varieties—to be set in twelve rows. These rows were 175 feet long and divided crosswise into four equal blocks or plots, with as many different methods of manuring and fertilizing. The manure and fertilizers, amounts and times of application of same, are identical with that outlined for asparagus. The only exception being that nitrate of soda on plot 4 is applied when the canes are approximately in full bloom.

The plantation was started in the spring of 1896. Rows were made five feet apart, with plants three feet apart in the row. In setting, one-half the manure and fertilizer was spread in the bottom of the furrow, while the remainder was put on the surface around the plant, after firmly setting it in place. Each year the spaces between rows have been thoroughly cultivated, commencing the latter part of April and continuing through the growing season.

Detailed results of the experiment have been published annually in the Station reports. Because of irregularities in stand, &c., only the product of the three red varieties are used in this discussion. The product of the first year from these varieties is also discarded. We have, therefore, the average of five seasons' product as the basis for our results.

Varieties.

The three red varieties are the Cuthbert, Marlboro and Turner.

Averaging the yields for the five crops upon all plots, and calculating the results to the basis of one acre, we have the following early and total yields for the three varieties. For comparison, the yields of 1903 are included. The crop of 1903 was the largest harvested in any season.

	Average Five Crops.		Crop of 1903.	
	Early.	Total.	Early.	Total.
Cuthbert	663.5 qts.	3,546.3 qts.	319.3 qts.	4,722.2 qts.
Marlboro	252.4 "	1,784.9 "	190.0 "	2,567.9 "
Turner	392.0 "	3,365.6 "	492.0 "	4,401.7 "

No attempt has been made to keep a record of the wholesale prices of raspberries in the local market. The prices given, *i. e.*, 16 cents per quart of early, and 11 cents for the total product.

are assumed, and are believed to represent fair average prices for the berries as prices have ranged in this market the past few seasons. The value of the early and total product per acre of each variety at these prices follow:

	Average Five Crops.		Crop of 1903.	
	Early.	Total.	Early.	Total.
Cuthbert	$106 16	$390 09	$51 09	$519 44
Marlboro	40 38	196 34	30 40	282 47
Turner	62 72	370 22	78 72	484 19

Cuthbert is unquestionably the "queen of the market" of these three varieties. Turner has proven nearly as productive, but the character and quality of the fruit render it almost worthless. Marlboro is about a week earlier than the Cuthbert, but not quite as vigorous in cane as desirable.

Fertilizers, Cost, Etc.

The general plan outlined has been followed without change in any respect. Table 8 gives the particulars of kinds, amounts and cost of manures and fertilizers applied.

Manure has been the most expensive method of supplying plant-food. The complete fertilizer on plot 2 gives the lowest annual cost, being but little over one-fourth that of the cost of manure for plot 1.

The fertilizers on plots 3 and 4, while costing considerably less than that of manure, cost 60 per cent. more and over double, respectively, that of the complete only, on plot 2.

Yields.

The early and total yields for each plot are given in Table 9, together with the value per plot, cost of manure per plot, and returns in value of crop for each dollar spent as manure or fertilizer.

The basis for determining the early yield is the first three pickings from each variety. This is an arbitrary division, but it represents roughly the period of highest prices in harvesting the crop.

TABLE 8.

Raspberries—Amount and Cost of Fertilizers Applied.

PLOT AND KIND OF FERTILIZER.	Amount applied each time.	Total amount applied to date.	Cost per ton.	Total cost per plot.	Average annual cost for for five years' producing.
	lbs.	lbs.			
Plot 1.—Manure	111.0	8,888.0	$1.50	$6.67	$1.33
Plot 2.—Complete fertilizer	13.9	111.2	30.80	1.71	.34
Plot 3.—Complete fertilizer	13.9	111.2	30.80	1.71	.54
Bone and potash	8.3	58.1	34.00	.99	
Plot 4.—Complete fertilizer	13.9	111.2	30.80	1.71	.72
Bone and potash	8.3	58.1	34.00	.99	
Nitrate of soda	5.5	38.5	45.00	.89	

TABLE 9.

Raspberries—Yields and Returns.

PLOT AND KIND OF FERTILIZER.	EARLY YIELDS.				TOTAL YIELDS.			
	Total early yield.	Value, 16c. per quart.	Annual cost of manure or fertilizer.	Returns per dollar of cost for manure or fertilizer.	Total yields.	Value, 11c. per quart.	Annual cost of manure or fertilizer.	Returns per dollar of cost for manure or fertilizer.
	qts.				qts.			
Plot 1.—Manure	13.3	$2.13	$1.33	$1.60	73.6	$8.10	$1.33	$6.09
Plot 2.—Complete fertilizer	12.6	2.02	.34	5.94	83.9	9.23	.34	27.15
Plot 3. Complete fertilizer... Bone and potash......	11.7	1.87	.54	3.46	86.5	9.52	.54	17.63
Plot 4. Complete fertilizer... Bone and potash...... Nitrate of soda.........	10.4	1.66	.72	2.31	75.4	8.29	.72	11.51

In early yields from the different plots, plot 1 stands first and the others in order as numbered. In the total yields, however, plot 3 has given the largest quantity and value, with plot 2 second in order, and with plot 1 lowest in productiveness and value.

Considered on the cost basis, however, the relations change considerably.

Plot 1. Manure, costing annually $1.33 per plot, has given a return per each dollar spent for manure of $1.60 and $6.09, respectively, for the early and total yields.

Plot 2. Complete fertilizer only, costing 34 cents annually, has returned for each dollar spent $5.94 and $27.15, respectively.

Plot 3. Complete fertilizer, with the addition of bone and potash in the fall, costing 54 cents, returns per dollar, $3.46 and $17.63, in order, while

Plot 4. Complete fertilizer, with bone and potash and with nitrate of soda additional, costing 72 cents, returns for each dollar's worth of fertilizer applied $2.31 in early product and $11.51 in total yields.

From the standpoint of economy in cost of plant-food, plot 2, complete fertilizer only, applied in the spring, has given the best results. In comparison with manure, the annual cost is practically one-fourth as much, while the return for each dollar's worth of fertilizer applied has been over four times that from the use of manure.

Calculating the relative value of manure on basis of returns from use of the complete fertilizer, it is found to be worth only 38.35 cents per ton.

The fertilizers used on plot 3, *i. e.*, complete with the addition in the fall of bone and potash, while giving the largest total yield, returns, per dollar's worth of fertilizer, only 65 per cent. of that obtained from the use of the complete alone on plot 2. It has, however, returned nearly three times that obtained for each dollar spent for manure on plot 1.

Plot 4. Complete fertilizer, with bone and potash in the fall, and with nitrate of soda at blossoming time, returns for each dollar's worth of fertilizer nearly double that from the use of manure, but considerably less than half that from the use of complete fertilizer alone.

Calculating the yields and values given for the different plots on Table 9, to the basis of one acre, we obtain the figures given in Table 9a.

The first column gives the annual cost per plot for manure or fertilizer for the five crops harvested. Under the average of five crops is found the amount of early yield, its value, the total product, its value, and the value of the crop, deducting cost of manure or fertilizers and cost of picking at three cents per quart.

The product of 1903, its value, and value less average cost of manure or fertilizers, and cost of picking at three cents per quart, is given for comparison and as representing the possible yield from a mature, producing plantation.

TABLE 9a.

Raspberries—Yields and Returns per Acre.

PLOT AND KIND OF FERTILIZER.	Average annual cost of manure or fertilizer—five crops.	AVERAGE OF FIVE CROPS.					CROP OF 1903.		
		Early yield.	Value, 16c. per quart.	Total yield.	Value, 11c. per quart.	Value, less cost of manure or fertilizer and picking at 3c. per quart.	Total yield.	Value, 11c. per quart.	Value, less cost of manure or fertilizer and picking at 3c. per quart.
		qts.		qts.			qts.		
Plot 1.—Manure	$48.40	482.8	$77.25	2671.7	$293.89	$165.34	3554.1	$390.95	$235.93
Plot 2.—Complete fertilizer	12.34	457.4	73.18	3045.6	335.02	231.31	4169.4	458.63	321.21
Plot 3. { Complete fertilizer, Bone and potash }	19.60	424.7	67.95	3140.0	345.40	231.60	4082.0	449.02	306.96
Plot 4. { Complete fertilizer, Bone and potash, Nitrate of soda }	26.14	377.5	60.40	2737.0	301.07	192.82	3783.5	416.19	276.54

The average annual cost per acre of manure and fertilizers for the five producing years is shown to be $48.40 for manure, $12.34 for the complete fertilizer alone, applied upon plot 2, and $19.60 and $26.14, respectively, for the mixtures applied upon plots 3 and 4.

Considering the averages of the five crops harvested from the field, the early yields from the plots are as numbered, plot 1 giving the largest, and plot 4 the lowest, in order.

In total yields, however, the manured plot, No. 1, gives the lowest yields, and hence lowest values and returns. Plot 3 has given the largest total product. The cost of fertilizers applied upon plot 3 is but 40.5 per cent. that of the manure used upon plot 1, and the yield is 17.5 per cent. greater than contained from plot 1.

Plot 2 is second in total yield, but giving very little less than that upon plot 3. Compared with plot 1, the fertilizer cost is but 25.5 per cent. that of manure, but the resulting yield is greater by 14 per cent.

Deducting the cost of manure or fertilizers applied, and also cost of picking at three cents per quart, the net returns from plots 2 and 3 are practically identical—twenty-nine cents in favor of plot 3.

In the crop of 1903, the general results are the same as in the average of the five crops. Plot 1, manure, has given lowest yields and values. The only exception to the general result is that plot 2 exceeds plot 3 in yields, values and net returns. The excess over plot 3 is, however, not large.

While results have varied from year to year, the average of five crops shows that the manure has cost the most per year, and has been the least effective of the four methods of fertilizing outlined. The averages show, also, that the mixture used upon plot 3, *i. e.*, complete fertilizer in the spring and bone and potash in the fall, has given the largest total yield, but compared with plot 2, *i. e.*, complete fertilizer alone, the fertilizer cost is 59 per cent. greater with net results practically identical.

The mixture used upon plot 4, costing a little over one-half that of the manure used upon plot 1, gives a larger total yield than does plot 1, but compared with plots 2 or 3, the cost is over twice and 33 per cent. greater, respectively, with net returns only 83.4 per cent. and 83.2 per cent. that of plots 2 and 3, in order.

Summary.

1. Cuthbert is by far the best market berry of the three in the test. Marlboro is valuable for earliness. Turner is discarded.

2. Manure, at $1.50 per ton, is the most expensive of the four methods of fertilizing practiced, while the total yields and the returns per dollar of cost are the lowest obtained.

3. The complete fertilizer used upon plot 2 has given the lowest annual cost, practically one-fourth that of manure used upon plot 1, and has given a return per dollar of cost for fertilizers over four times that obtained from the use of manure upon plot 1, and 54 per cent. greater than that from mixture used upon plot 3.

4. In total yield, however, plot 2 is second to plot 3, though by less than 100 quarts per acre, and with net returns practically identical.

5. The fertilizers applied to plot 3, *i. e.*, complete in the spring and bone and potash in the fall, give the largest total yield and net returns, but cost annually 59 per cent. more than that of the complete alone upon plot 2. Compared with manure, however, the returns per dollar of cost are practically three times as great from a cost for fertilizer only 40.5 per cent. that of manure.

6. The addition of nitrate of soda at blossoming time has proved valueless, as far as increasing production, upon plot 4. The total yield, however, is greater than that from the manured plot and the annual cost is but little over half that of the manure applied to plot 1.

Raspberries—Crop of 1903.

The plantation was trimmed the last of March, and spaces between rows cultivated April 22d. Manure as per plan was applied upon plots 1 and 5 December 27th, and bone and potash applied to plots 3, 4, 7 and 8 December 22d. The complete fertilizer for plots 2, 3, 4, 6, 7 and 8 was applied April 29th, and the nitrate of soda for plots 4 and 8 on May 27th. The irrigated plots, 5 to 8, received water three times, *i. e.,* May 13th, 26th and June 2d, applying the equivalent of an inch of rainfall each time.

The records of the year, together with the annual records per plot for previous years, are given in Table 10.

The crop of 1903 was the largest taken from the patch. Because of irregularities in stand, and undesirable varieties, it was decided, after harvesting this year's crop, to destroy the present planting of all varieties except the Cuthbert and to renew the coming spring. The varieties to be planted have not as yet been determined.

Considering the year's results by plots, we have:

a. In early yields, one plot only, No. 7, of those irrigated exceeds its unirrigated duplicate. Plots 2 and 6, duplicates, are practically identical. In total yields also, plot 7, irrigated, exceeds but slightly its unirrigated duplicate.

In the averages of the six crops harvested, the early yields of the irrigated plots exceed in two and are identical in the third plot. Plot 4, only, of those not irrigated exceeds the irrigated duplicate.

In total yields, plot 2, only, of those unirrigated has given a larger yield than the irrigated plots. Combining results from all four plots, in each case those irrigated have the larger yield by a little over 2 per cent.

b. The relations between the different plots vary considerably where irrigated, and where not irrigated from that of previous seasons.

TABLE 10.

Raspberries—Fertilizer Plots.

VARIETY.	Date first picking.	UNIRRIGATED.							
		PLOT 1.		PLOT 2.		PLOT 3.		PLOT 4.	
		Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings	Total yield	Yield first three pickings.	Total yield.
		oz.	oz	oz.	oz	oz.	oz.	oz.	oz.
Cuthbert	July 24.	35.9	492.0	25.0	570.0	37.0	644.0	33.0	328.0
Marlboro	" 17.	33.5	192.0	13.5	282.0	18.0	280.0	17.5	281.0
Turner	" 19.	91.0	468.0	43.5	483.0	30.5	392.0	53.0	540.0
Gregg	" 24.	14.0	147.0	7.5	85.0	8.0	74.0	13.0	95.0
Souhegan	" 24.	166.0	435.0	76.0	264.0	85.5	219.0	77.0	218.0
Total		344.4	1734.0	165.5	1684.0	179.0	1609.0	193.5	1462.0
Equivalent in quarts		15.7	78.8	7.5	76.5	8.1	73.1	8.8	66.5
Total in quarts for 1898*		7.0	23.7	2.4	11.7	2.4	11.4	2.6	10.3
Total in quarts for 1899*		12.4	38.4	6.1	37.2	6.0	38.3	3.0	24.2
Total in quarts for 1900*		2.9	33.6	7.7	46.8	5.8	49.5	3.2	36.8
Total in quarts for 1901		6.0	31.7	12.1	44.3	12.2	43.7	13.2	42.2
Total in quarts for 1902		14.7	53.3	11.6	52.4	10.7	52.0	8.2	46.6
Average in quarts, six crops		9.8	43.3	7.9	44.8	7.5	44.7	6.5	37.8

* Three varieties only.

Raspberries—Fertilizer Plots.

VARIETY.	Date first picking.	IRRIGATED.							
		PLOT 5.		PLOT 6.		PLOT 7.		PLOT 8.	
		Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.
		oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
Cuthbert	July 24.	32.0	403.0	31.0	524.0	29.5	395.0	31.0	460.0
Marlboro	" 17.	27.5	207.0	12.5	267.0	16.0	292.0	15.0	274.0
Turner	" 19.	72.5	392.0	37.0	401.0	39.5	471.0	30.5	410.0
Gregg	" 24.	9.0	93.0	6.5	28.0	8.5	77.0	10.5	45.0
Souhegan	" 24.	64.5	239.0	73.5	250.0	109.5	377.0	61.5	227.0
Total		205.5	1334.0	160.5	1470.0	203.0	1612.0	148.5	1416.0
Equivalent in quarts		9.3	60.6	7.3	66.8	9.2	73.3	6.8	64.4
Total in quarts for 1898*		8.7	41.5	2.9	14.0	2.8	13.6	2.2	11.2
Total in quarts for 1899*		12.0	40.6	7.3	39.3	6.0	41.5	6.0	32.2
Total in quarts for 1900*		4.5	37.5	5.5	40.5	4.8	47.4	3.9	39.5
Total in quarts for 1901		9.2	39.0	11.4	39.0	13.5	45.9	9.8	38.7
Total in quarts for 1902		16.0	65.5	13.2	51.9	12.7	55.0	9.9	48.7
Average in quarts, six crops		10.0	47.5	7.9	41.9	8.2	46.1	6.4	39.1

* Three varieties only.

In early yield, unirrigated, plot 1 leads; plot 4 is second, and plot 2 lowest. Irrigated, the order is plot 5 and plot 7, first and second, though practically identical, with plot 8 lowest.

In total yields, where unirrigated, the plots stand in order as numbered, *i. e.*, plots 1, 2, 3 and 4. Where irrigated, however, plot 7 leads, 6 is second, with 5 the lowest, in order.

In the averages for the six crops, the order of plots in early yield is with one exception as numbered, both where irrigated and where unirrigated. The exception is that the irrigated plot 7 exceeds No. 6. In total yields, plot 2 is first where not irrigated, and plot 5 where irrigated. Thereafter the relations are the same upon the irrigated and unirrigated plots, *i. e.*, plots 3 and 7 second, and 4 and 8 lowest in order.

c. Plot 4, unirrigated, receiving the extra nitrate of soda, stands second in early and fourth in total yields. The irrigated duplicate, plot 8, is lowest in early and third in total yields.

In the average of the six crops, plots 4 and 8 have the lowest yields in every case.

Blackberries.

The blackberry patch has been trimmed, cultivated, fertilized and irrigated, along with the raspberry patch, and hence the same dates apply.

The detailed records of the crop of 1903, and the records of plots for the five previous crops, are given in Table 11.

Combining the yields from all plots for each variety, we have the following figures from equal areas:

Early Harvest	3,926.0	Agawam	2,080.5
Wilson, Jr.	2,256.5	Taylor	3,116.0
Erie	3,807.0	Eldorado	3,874.5

Early Harvest has given the largest yield, with Eldorado and Erie next in order.

Taking the results by plots we have:

a. On only one of the irrigated plots has any increase been obtained. The early yield of plot 8 slightly exceeds its unirrigated duplicate.

TABLE 11.

Blackberries—Fertilizer Plots.

VARIETY.	Date first picking.	UNIRRIGATED.							
		PLOT 1.		PLOT 2.		PLOT 3.		PLOT 4.	
		Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.
		oz.	oz	oz.	oz.	oz	oz.	oz.	oz.
Early Harvest	July 6.	383.0	580.5	288.0	510.5	336.0	535.0	304.0	494.0
Wilson, Jr	" 15.	41.5	114.5	92.0	414.0	87.5	607.0	96.0	673.0
Erie	" 15.	76.0	520.0	50.0	401.5	50.0	525.0	56.0	732.5
Agawam	" 15.	29.2	421.5	11.5	131.0	26.0	263.0	6.0	242.5
Taylor	" 15.	63.5	764.5	23.0	206.0	8.0	380.0	15.0	411.0
Eldorado	" 8.	134.0	595.0	95.0	635.5	59.0	297.5	88.0	491.5
Total	....	727.2	2996.0	559.5	2298.5	566.5	2607.5	565.0	3044.5
Equivalent in quarts	....	30.3	124.8	23.3	95.8	23.6	108.6	23.5	126.9
Total in quarts for 1898	....	13.3	87.4	16.4	71.5	24.4	87.2	14.8	52.1
Total in quarts for 1899	....	8.9	39.6	10.7	61.3	16.2	101.1	15.0	90.0
Total in quarts for 1900	....	35.7	212.8	32.2	209.6	29.4	196.8	32.8	177.8
Total in quarts for 1901	....	11.3	47.0	10.7	66.5	7.8	48.5	8.2	51.1
Total in quarts for 1902	....	6.3	17.3	5.3	24.4	5.6	26.8	9.1	37.8
Average in quarts six crops	....	17.6	88.2	16.4	88.2	17.8	94.8	17.2	89.3

Blackberries—Fertilizer Plots.

VARIETY.	Date first picking.	IRRIGATED.							
		PLOT 5.		PLOT 6.		PLOT 7.		PLOT 8.	
		Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.	Yield first three pickings.	Total yield.
		oz.	oz.	oz	oz.	oz.	oz.	oz.	oz.
Early Harvest	July 6.	275.0	372.0	277.0	401.5	378.5	535.5	357.0	497.0
Wilson, Jr	" 15.	12.0	129.0	35.0	113.0	12.0	67.5	36.5	138.5
Erie	" 15.	71.5	499.5	34.0	335.0	27.0	352.0	39.0	441.5
Agawam	" 15.	48.5	358.0	10.5	139.0	15.5	277.0	19.0	248.5
Taylor	" 15.	15.5	497.5	8.0	285.0	12.5	261.5	17.5	310.5
Eldorado	" 8.	134.5	553.5	79.5	553.5	75.5	383.5	100.0	364.5
Total	....	557.0	2409.5	444.0	1827.0	521.0	1877.0	569.0	2000.5
Equivalent in quarts	....	23.2	100.4	18.5	76.1	21.7	78.2	23.7	83.4
Total in quarts for 1898	....	27.2	161.1	29.5	103.1	20.8	67.6	20.0	55.6
Total in quarts for 1899	....	18.3	98.7	17.0	148.9	18.0	131.7	16.0	119.6
Total in quarts for 1900	....	41.2	207.0	34.7	195.9	33.8	146.4	29.1	142.0
Total in quarts for 1901	....	15.2	73.4	12.4	70.0	8.2	43.7	9.7	49.3
Total in quarts for 1902	....	7.0	26.7	6.2	25.5	4.2	22.5	7.6	34.8
Average in quarts, six crops	....	22.0	111.2	19.7	103.3	17.8	81.7	17.7	80.8

In the average of the six crops, the early yield of the irrigated plots exceed in three and are identical on the fourth plot. In total product, two of the irrigated plots exceed, and two are exceeded by their unirrigated duplicates. Taken together the irrigated plots lead in yield by over 4½ per cent.

b. The relations between plots vary considerably. In early yield plot 1 is first, with little difference between the other unirrigated plots. Under irrigation, plot 8 leads, with 5 second.

In total yields upon the unirrigated plots, number 4 has the greatest yield, plot 1 is second in order, and 2 is the lowest. Where irrigated, plot 5 leads, 8 is second and 6 lowest.

In the averages of the six crops, plots 3 and 5 stand first, with 2 and 8 lowest in early yields.

The total yields where irrigated are in order as plots are numbered, *i. e.*, plots 5, 6, 7 and 8. Where not irrigated, plot 3 has the largest yield, plot 4 second, and plots 1 and 2 are identical.

c. Nitrate of soda added to plot 4, has given the largest total, but stands third in early yields. Upon plot 8, irrigated, the largest early yield is obtained, and is second in order in total yields.

In the combined averages, plot 4 is third in early and second in total, but plot 8, its duplicate, under irrigation, has the lowest yield in both cases.

Currants and Gooseberries.

Manure was applied as per plan upon plots 1 and 5, December 27th. The usual mixture of bone, potash and acid phosphate was applied to the other four plots, in each case, December 22d. Bushes were trimmed in March, and ground between rows cultivated for the first time for season, April 22d. As an insurance against leaf blight, which has shown signs of becoming troublesome, the plants have been well sprayed as needed with Bordeaux and Paris green added for any currant worms that might develop. The result has been that the plants or bushes have held their foliage better and longer this fall than has been usual.

Currants.

A comparison of varieties for 1903 is shown by the following figures, equal areas in each case:

Fay's Prolific	1,658.5	Victoria	2,792.0
Red Dutch	3,423.0	White Grape	335.5

In last year's report* the yields were given of a number of bushes of the variety Fay's Prolific, giving good and poor yields under identical treatment. That is, good and poor bushes were selected from the same plots, so that methods of fertilizing were not the cause of differences resulting.

The records of these same bushes are included in the following table, No. 12. The bushes were set in the spring of 1896. The yields given are the total product of each bush since setting. The averages per bush for annual yield is small, because the light yields of the years 1897 and 1898 are included in averaging.

TABLE 12.

Record of Individual Currant Bushes, Giving Uniformly High and Low Yields.

NUMBER OF PLOT AND BUSH.	HIGH YIELDS. Yield during life of bush.	Average per year.	Calculated yields per acre.	NUMBER OF PLOT AND BUSH.	LOW YIELDS. Yield during life of bush.	Average per year.	Calculated yields per acre.
	oz.	oz.	qts.		oz.	oz.	qts.
Plot 1—Bush 3	266.5	38.1	3,951.0	Plot 1—Bush 7	188.0	26.9	2,789.5
Plot 2—Bush 3	374.5	53.5	5,548.0	Plot 2—Bush 7	248.5	35.5	3,681.4
Plot 2—Bush 6	374.0	53.4	5,357.6	Plot 3—Bush 4	26.5	3.8	394.1
Plot 3—Bush 2	342.0	48.9	5,070.9	Plot 3—Bush 7	26.0	3.7	383.7
Plot 3—Bush 5	307.5	43.9	4,552.4	Plot 4—Bush 5	171.5	24.5	2,540.7
Plot 4—Bush 3	360.0	51.4	5,330.2	Plot 4—Bush 7	49.0	7.0	725.9
Plot 4—Bush 4	383.0	54.7	5,672.4	Plot 5—Bush 5	57.0	8.1	840.0
Plot 5—Bush 2	305.5	43.6	4,521.3	Plot 5—Bush 7	32.5	4.6	477.0
Plot 6—Bush 7	415.0	59.3	6,149.4	Plot 6—Bush 3	87.5	12.5	1,296.3
	....	....	....	Plot 6—Bush 5	62.0	8.9	922.9
Average	347.6	49.6	5,128.1	Average	94.9	13.6	1,405.2

* Annual Report for 1902, page 258.

The value of the individual plant or tree in fruit-growing is of great importance if these figures mean anything at all.

In the third column in each case, yields at the rate of each individual bush are calculated to the basis of one acre. In those giving good yields, the range is from 3,951.0 to 6,149.4 quarts per acre, averaging 5,128.1 quarts. The average of those of low-producing capacity is 1,405.2 quarts per acre. Calculating the yields per acre on basis of yield of all the bushes of this variety, Fay's Prolific, in the plots, we have 2,867.5 quarts. These bushes were good, average plants sold by nurserymen. These large differences in yields show the possibilities in currant growing, and offer strong incentives to build up profitable currant plantations by propagating from the most productive bushes.

Taking the plot work for 1903, Table 13, we have—

a. Plot 2, only, of those unirrigated exceeds its irrigated duplicate. Taken together, the irrigated plots exceed by 7 per cent. the yield of those unirrigated.

In the average of the six crops, the irrigated plots exceed in every case the yield of those not irrigated, and together give 9½ per cent. more fruit than obtained where not irrigated.

b. The results of the crop of 1903 and the averages of the six crops are practically the same. Plots 1 and 4, manure, give the largest yields. Plots 3 and 6, the mixture of bone, potash and acid phosphate, with nitrate added, are second in order, while plots 2 and 5, the mixture only, are lowest in yields.

c. The plots receiving the extra nitrate of soda are second in yield in every case.

Gooseberries.

Yields of the four varieties in 1903 are:

Downing	6,016 oz.
Houghton	7,013 "
Triumph	2,238 "
Columbus	3,002 "

TABLE 13.

Currants—Fertilizer Plots.

VARIETY.	UNIRRIGATED.			IRRIGATED.		
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
	oz.	oz.	oz.	oz	oz.	oz
Fay's Prolific	287.0	471.0	238.0	207.0	187.0	269.0
Red Dutch	720.0	341.0	505.0	725.0	558.0	574.0
Victoria	420.0	368.0	441.0	661.0	415.0	487.0
White Grape	77.0	35.0	63.0	65.0	25.0	71.0
Total	1,504.0	1,215.0	1,247.0	1,658.0	1,185.0	1,401.0
Equivalent in quarts	75.2	60.8	62.4	82.9	59.3	70.1
Total in quarts for 1898	13.3	3.4	8.8	17.8	11.3	9.4
Total in quarts for 1899	41.2	37.5	49.8	51.8	51.6	50.9
Total in quarts for 1900	67.2	61.0	53.9	82.0	68.1	60.5
Total in quarts for 1901	109.9	98.0	108.0	129.8	105.0	107.3
Total in quarts for 1902	139.9	119.0	135.6	143.2	113.8	150.2
Average in quarts, six crops	74.5	63.3	69.8	84.6	68.2	74.7

Gooseberries—Fertilizer Plots.

VARIETY.	UNIRRIGATED.			IRRIGATED.		
	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
	oz.	oz.	oz.	oz.	oz.	oz.
Downing	1,768.0	1,087.0	1,016.0	1,758.0	977.0	946.0
Columbus	395.0	148.0	191.0	366.0	107.0	324.0
Houghton	1,134.0	883.0	734.0	1,058.0	616.0	602.0
Triumph	259.0	254.0	147.0	580.0	80.0	315.0
Total	3,556.0	2,327.0	2,088.0	3,762.0	1,780.0	2,187.0
Equivalent in quarts	151.3	99.0	88.9	160.1	75.7	93.1
Total in quarts for 1898	29.7	22.9	26.4	37.5	21.8	24.8
Total in quarts for 1899	86.3	47.5	74.6	70.6	59.5	66.2
Total in quarts for 1900	158.7	93.2	125.0	161.9	123.4	134.5
Total in quarts for 1901	47.2	34.9	31.3	44.2	40.6	45.0
Total in quarts for 1902	151.3	99.0	88.9	160.1	75.7	93.1
Average in quarts, six crops	104.1	66.9	72.5	105.7	66.1	76.1

Houghton has the smallest berry, while Downing has a berry one-third to one-half larger. The bushes of these varieties are large and strong. Triumph and Columbus have berries twice or three times the size of Houghton. The bushes are, however, hardly half the size of Houghton or Downing. They may be set considerably closer than the latter. By plots, we have for gooseberries—

a. An increase given by plots 4 and 6, irrigated, over 1 and 3, not irrigated. Plot 2 exceeds plot 5 in yield. Taken together, the unirrigated rows giving a little the larger yields. Averaging the six crops, the plots stand in the same order as in 1903, but taken together those irrigated give slightly the larger yield.

b. With one exception, plot 3, 1903, the relations of plots are the same throughout, *i. e.,* in order plots 1 and 4, 3 and 6, and 2 and 5. Plot 2 exceeds plot 3 in yield in 1903.

c. With the above exception, plots 3 and 6, receiving the application of nitrate of soda, have given the second largest yields throughout.

Strawberries—Fertilizer Plots.

The land devoted to the strawberry plot work was plowed down after the fruiting season in 1902 and sown to cow peas. The proper bacteria were evidently not present in the soil, and only a poor growth of pea vines was obtained. Early in 1903 the land was plowed and thoroughly fitted and plants of the following varieties were set as in the previous work. Five varieties were used instead of six, dropping one variety because of proximity to the plum orchard:

Glen Mary,	Marshall,
Bubach,	Lady Thompson,
Gandy.	

The spring applications of fertilizers were made as per plan, but the application of nitrate of soda was omitted. The irrigated plots were watered twice, May 12th and 25th, giving an inch of water each time. The plants have made a good growth, but plots 6 and 7 show more than desirable the effects of the work of the white grub.

Strawberry—Varieties.

The variety test of strawberries was conducted under difficulties and is not fully satisfactory. The history of the patch follows:

The plants were purchased in the spring of 1901 and placed in pots until the land available for them was ready. It was then in strawberries, being the variety test reported in 1901. After fruiting, the foliage was mown and in due time was burned. Shavings had been used for mulch, and the refuse of bed burned only imperfectly. The ground was plowed and fitted, but it was not until July 31st that suitable conditions allowed the setting of the plants. Rows were set four feet apart, and plants eighteen inches apart in the row; ten plants of each variety were used, and all started well, but made no runners during the fall. In the meantime, the white grub got in his work.

The result was that in the spring of 1902 many plants had to be reset. Those remaining of the original plants were stronger, naturally, than those set in 1902, so that the bed looked very irregular. During 1902, however, the space allotted to the different varieties was well filled with runner plants.

A light dressing of fertilizer was given the plants at time of setting. In spring of 1902, also 1903, an application of the complete fertilizer at rate of 500 pounds per acre was given the patch. During the dry period of 1903 three applications of water were made, or a total of five inches, May 15th, 21st and 27th.

The record of the season's crop is given in Table 14. The area covered by each variety is given in the third column, but for strict comparison the yields are all calculated to the equivalent area of forty-five square feet. Comparative earliness is shown by yields before June 1st in first column, and the later sorts by yields after June 25th, in third column, under yields. The last column of figures are the calculated yields per acre.

TABLE 14.

Strawberries—Varieties.

VARIETY—GROWN IN MATTED ROWS.	Perfect and imperfect blossom.	Date of first picking.	Area covered by variety.	YIELDS CALCULATED TO AN EQUAL AREA. Yield before June 1st.	Total yield.	Yield after June 25th.	Yields per acre, calculated.
			sq. ft.	oz.	oz.	oz.	qts.
Amwell	Per.	May 22.	12.5	20.0	126.0	....	6,419
Aroma	"	" 28.	45.0	8.5	120.0	1.5	6,121
Auto	"	" 28.	56.5	6.0	181.5	1.5	9,239
Bennett	Imp.	" 26.	39.0	25.0	157.0	....	8,001
Bismark	Per.	" 26.	41.0	30.0	170.5	....	8,689
Blonde	"	June 1.	30.0	....	131.5	2.5	6,694
Brunette	"	May 28.	37.0	16.0	111.0	....	5,656
Bubach	Imp.	" 28.	37.5	24.0	129.0	....	6,573
Bush Cluster	Per.	" 28.	45.0	5.5	109.0	3.0	5,548
Carmi Beauty	Imp.	" 22.	37.5	36.0	186.5	....	9,492
Corsican	Per.	" 28.	42.0	7.5	121.0	....	6,167
Duff's	Imp.	" 22.	48.0	20.5	188.0	4.5	9,583
Emperor	Per.	" 28.	52.5	7.5	135.5	....	6,901
Empress	"	" 28.	49.0	8.5	156.5	1.5	7,978
Gandy	"	" 30.	41.0	1.0	168.0	8.0	8,558
Gibson	"	" 30.	45.0	1.0	150.0	4.5	7,642
Gladstone	"	" 28.	30.0	10.5	77.5	....	3,948
Glen Mary	"	" 26.	45.0	15.5	176.0	2.5	8,964
Howard's No. 2	Imp.	" 26.	52.5	20.5	231.5	....	11,784
Hunn	"	June 3.	45.0	....	133.0	10.5	6,786
Kansas	"	May 26.	45.0	21.0	126.0	....	6,419
Klondyke	Per.	" 30.	42.0	2.0	212.5	6.0	10,821
Lady Thompson	"	" 22.	45.0	21.5	94.0	....	4,792
Marie	Imp.	" 26.	52.5	5.5	198.0	4.5	10,088
McKinley	Per.	" 30.	18.0	4.0	144.0	....	7,336
Michel's Early	"	" 22.	48.0	16.0	42.5	....	2,163
Michigan	"	" 30.	14.0	5.0	117.0	....	5,961
Monakin	Imp.	" 22.	52.0	25.5	138.0	....	7,031
Nettie	"	June 1.	45.0	....	230.5	10.0	11,738
New York	"	May 30.	41.0	1.5	170.5	....	8,689
Nick Ohmer	Per.	" 30.	49.0	6.5	159.0	4.0	8,093
Paris King	"	" 22.	45.0	13.0	90.5	....	4,608
Pennell	"	" 26.	45.0	25.5	174.5	2.0	8,895
Parker Earle	"	" 22.	37.5	22.0	148.0	....	7,543
President	Imp.	" 28.	40.0	10.0	164.0	....	8,345
Rough Rider	Per.	" 26.	30.0	11.0	138.0	3.0	7,038
Sampie	Imp.	" 22.	52.5	33.5	210.0	2.5	10,707
Senator Dunlop	Per.	" 26.	52.5	32.0	232.0	1.5	11,821
Tennessee	"	" 30.	30.0	7.5	112.0	14.5	5,603
Warfield	Imp.	" 28.	42.0	3.0	108.5	....	5,525
Wm. Belt	Per.	" 30.	45.0	2.0	119.0	2.5	6,053
Woolverton	"	" 26.	37.5	16.0	169.0	....	8,611

The ten most productive sorts are in order:

Senator Dunlop,	Marie,
Howard's No. 2,	Duff's,
Nettie,	Carmi Beauty,
Klondyke,	Auto,
Sample,	Glen Mary.

The ten giving the largest yields before June 1st, are in order:

Carmi Beauty,	Pennell,
Sample,	Bennett,
Senator Dunlop,	Bubach,
Bismark,	Parker Earle,
Monakin,	Lady Thompson.

Those giving the best late yields are:

Tennessee,	Duff's,
Nettie,	Gibson,
Hunn.	Marie,
Gandy,	Nick Ohmer,

Klondyke.

The Tree Fruits.

The general plan follows: The plots extend crosswise the rows and include two trees of each row. Each row is a different variety. A cross-line of trees is set between plots to separate plots and prevent interfeeding and at the same time test some of the newer varieties of the different tree fruits. Thus arranged, trees 1, 2, 4, 5, 7 and 8, etc., of each row, are in the plots, while trees 3, 6 and 9, etc., are varieties. Table 15 shows in detail the plan for fertilizing, amounts and times of application.

The orchards were pruned during March; May 2d, nitrate of soda was applied to the plots indicated in the general plan, and the land plowed. The general application of fertilizers was made June 2d. On the 5th of June two inches of water was applied to the irrigated plots of plums, cherries and dwarf pears.

We have to record this year the presence of the San José scale. It is so well scattered through the orchards that a general spraying will be necessary. A couple of apple trees and a few of the peach trees have been sprayed during the fall with Good's potash-whale oil soap, to prevent too great a multiplication during the fall months.

TABLE 15.

Showing Fertilizer, Amounts and Time of Application for the Various Fruit Trees.

KIND OF FRUIT.	Plot 1.	Plot 2.	Plot 3.	Plot 4.
Apples	Nothing.	500 lbs.‖ B. P. & A. P.† applied in spring.	500 lbs. B. P. & A. P. applied in spring.	
Peaches	Nothing.	500 lbs. B. P. & A. P. applied in spring.	500 lbs. B. P. & A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.	500 lbs. B. & A. P.‡ applied in spring; 150 lbs. nitrate soda applied early and turned under.
Standard Pears	Nothing.	500 lbs. B. P. & A. P. applied in spring.	500 lbs. B. P. & A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.	
	Plots 1 and 4.*	Plots 2 and 5.	Plots 3 and 6.	
Dwarf Pears	Nothing.	500 lbs. B. P. & A. P. applied in spring.	500 lbs. B. P. & A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.	
	Plots 1 and 3.*	Plots 2 and 4.		
Plums, Cherries	500 lbs. B. P. & A. P. applied in spring.	500 lbs. B. P. & A. P. applied in spring; 150 lbs. nitrate soda applied early and turned under.		

‖ The quantities of fertilizers given are in all cases the amount per acre to be applied.

† An even mixture of ground bone, muriate of potash and acid phosphate.

‡ A mixture of muriate of potash and acid phosphate in the proportion of 1 lb. of the former to 2 lbs. of the latter.

* Plots 1, 2 and 3, Dwarf Pears, and 1 and 2, Plums and Cherries, are irrigated as occasion demands.

PLUMS AND CHERRIES.

Of the plums, Newman only carried anything like a crop, though the other three varieties in plot work bore a little fruit. The early blooming varieties, like Burbank, Abundance and Satsuma, were nipped in blooming by the late frosts.

The cherry orchard was in full bloom at the time of thirty-two degrees temperature of May 2d, yet several of the varieties set and matured a large crop of fruit. Either these varieties are more hardy, or else, as seems more likely, the blossoms had reached a stage sufficiently advanced in period of pollination to withstand effect of low temperatures, while the bloom of those varieties in which pollination had not yet taken place was killed.

The detailed records of the year and totals per plots for previous crops are given in Table 16. Definite conclusions, particularly with plums, are not to be drawn, because of great variations in yields of different trees, even on same plots, especially true of Newman. Note yields of this variety in plot 3. One tree gives a total of 161 pounds and five ounces, while the second gives only seven pounds and eleven ounces. Considering, however, with this fact in mind, the average of the five crops, the irrigated plots 1 and 2, give larger yields than the unirrigated plots, both for plums and cherries.

Plot 2, irrigated, receiving the early application of nitrate of soda, gives considerably larger yields than plot 1, its duplicate, without nitrate. Where not irrigated, however, the plot 4, receiving the nitrate, is lower in yield than its duplicate without nitrate.

Combining the yields of the two plots, with and without the application of nitrate of soda, that of the plums without the nitrate exceeds that with, but in cherries the nitrate plots give the largest yields.

TABLE 16.

Plums and Cherries—Fertilizer Plots.

VARIETY.	Date marketable.	IRRIGATED.				UNIRRIGATED.			
		PLOT 1.		PLOT 2.		PLOT 3.		PLOT 4.	
		TOTAL YIELD.		TOTAL YIELD.		TOTAL YIELD.		TOTAL YIELD.	
		Tree 1.	Tree 2.	Tree 1.	Tree 2.	Tree 1.	Tree 2.	Tree 1.	Tree 2.
Plums.		lbs. oz.	lbs. oz.	lbs. oz	lbs. oz.	lbs. oz.	lbs. oz.	lbs. oz	lbs. oz.
Lombard—Good....	Aug. 31.	0— 5	0— 3	....	0— 5	0— 2	....	0— 1	4— 3
Lombard—Rotten..	....	0— 2	0— 9	....	13— 9	1— 6	3—12	0— 2	19— 2
Newman—Good.....	Aug. 5.	12— 7	48— 7	9—12	36— 6	81— 2	4— 1	2—13	3—11
Newman Culls.......	....	16—13	24— 4	6—15	48— 6	80— 3	3—10	2—10	1—12
Shropshire Damson —Good................	Sept. 8.	0— 6	1—15	0— 8	0—11	0— 2	7—14	0—14	2— 1
Shropshire Damson —Rotten..	....	1— 0	2— 1	0— 8	0—12	....	5—15	0—13	2— 5
Grand Duke—Good	Sept. 12.	0— 2	....	0— 5	0— 8	....	0— 9	0— 2	0— 9
Grand Duke—Rotten....................	....	....	0— 3	0—10	1— 1	....	0— 6	0—15	1— 9
Total................	....	31— 3	77—10	18—10	101—10	162—15	26— 3	8— 6	35— 4
Total per plot..	....	108—13	....	120— 4	....	189— 2	....	43—10	....
Total per plot 1899................	....	25— 7	....	33— 6	....	46— 7	....	5— 9	....
Total per plot 1900................	....	112—13	....	172— 3	....	182—12	....	35— 6	....
Total per plot 1901................	....	5— 8	....	14— 4	....	15—12	....	2— 6	....
Total per plot 1902................	....	434—13	....	438—14	....	517— 6	....	233— 0	....
Average, five crops.............	....	137— 8	....	155—13	....	190— 5	....	64— 0	....
Cherries.									
Louis Philippe.......	June 17.	0—13	3— 2	9— 3	4— 3	1— 9	0— 6	6—13	4—13
Early Richmond ...	June 9.	0—10	4— 3	3— 6	7— 7	1— 9	2— 5	7—11	3— 5
Total	....	1— 7	7— 5	12— 9	11—10	3— 2	2—11	14— 8	8— 2
Total per plot...	....	8—12	....	24— 3	....	5—13	....	22—10	....
Total per plot 1899................	....	0— 4	....	0— 8	....	0—10	....	0— 6	....
Total per plot 1900................	....	10— 2	....	9—12	....	17—11	....	8— 3	....
Total per plot 1901................	....	9—13	....	14— 9	....	12—14	....	9— 1	....
Total per plot 1902................	....	35—13	....	67— 2	....	46—15	....	33—12	....
Average, five crops..........	....	12—15	....	23— 4	....	16—15	....	14—13	....

Varieties.

The records of the different varieties are given in Table 17. In the last two columns in this table the average annual yield to date is given and the number of years of fruiting. Similar records are given of the varieties in plot work for comparison.

These trees have now been set eight years, and a study of these two columns shows which are early maturing and productive. In plums, Newman has fruited five seasons, Lombard and Burbank four, while the variety Washington has not yet produced a single fruit.

Several varieties of cherries have fruited five seasons, and two, particularly, have given large yields, *i. e.,* English Morello and Montmorency Ordinaire. The standard, Large Montmorency, has fruited three seasons, but has averaged only a half pound of fruit per tree.

DWARF PEARS.

The records of the year are given in Table 18, together with the totals per plot for the three previous years of fruiting.

It is too early in the life of the orchard for definite conclusions. However, the indications are that irrigation is beneficial. In 1903's crop, and the average of the four crops, the irrigated plots have given decidedly the larger yields.

The results by plots are not regular, but combining the yields of the duplicate plots in each case, we have as the average of four crops:

No fertilizer	351 fruits,	91 lbs.	12 oz.	4.2 oz.	average per fruit.
The mixture alone	351 "	104 "	2 "	4.7 "	" " "
The mixture + nitrate	343 "	110 "	2 "	5.1 "	" " "

The crop of 1903 gives the same results as above, only greater in extent, between the plots. The plot receiving no fertilizer is lowest in yield and average size of fruit, while the plot receiving the general mixture with the early application of nitrate has given the largest yields and the largest-sized fruits.

TABLE 17.

Plums and Cherries—Varieties.

VARIETY.	Date marketable.	1903. TOTAL YIELDS. Tree 1.	Tree 2.	Trees set spring 1895. Average yield per tree to date, including varieties in permanent plot for comparison.	Number years bearing more or less fruit.
Plums.		lbs. oz.	lbs. oz.	lbs. oz.	
Imperia Gage	Sept. 8.	0— 6	1— 3	1— 7	2
Victoria	Aug. 31.	8— 9	5— 4	3—13	2
Bavay's Green Gage	......	......	......	8—10	3
Burbank	......	......	......	22—12	4
Abundance	......	......	......	24— 5	2
French Damson	Sept. 8.	6—12	5— 6	1— 5	3
Satsuma Blood	......	......	......	22—10	2
Washington	......	......	......	......	......
Lombard	......	......	......	28— 8	4
Newman	......	......	......	41— 7	5
Shropshire Damson	......	......	......	8— 3	3
Grand Duke	......	......	......	3— 3	3
Cherries.					
Ostheim	June 17.	14—13	13—13	4— 9	5
Royal Duke	" 15.	43—15	23— 2	11— 4	4
English Morello	" 30.	70—15	27— 2	18— 9	5
Montmorency Ordinaire	" 24.	45— 3	59—14	20— 8	5
Reine Hortense	" 15.	1— 0	0— 2	2— 2	5
May Duke	" 4.	2—13	2— 9	7—13	5
Large Montmorency	......	......	......	0— 8	3
Louis Philippe	......	......	......	1—14	4
Early Richmond	......	......	......	6—14	5

TABLE 18.

Dwarf Pears—Fertilizer Plots.

VARIETY.	IRRIGATED.																	
	PLOT 1.						PLOT 2.						PLOT 3.					
	TREE 1.			TREE 2.			TREE 1.			TREE 2.			TREE 1.			TREE 2.		
	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.
Dwarfs.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.
Lawrence	10	2— 3	3.5	16	3— 7	3.4	25	5— 5	3.4	40	9— 9	3.8	40	10— 6	4.2	41	10— 6	4.0
Bartlett	......	....	......	1	0— 6	6.0	39	10— 1	4.1	43	14—10	5.4	118	39— 0	5.3	141	44— 5	5.0
Dwarfs by Cutting.																		
Lawrence	......	....	......	2	0— 4	2.0	......	....	......	7	3— 5	7.6	......	....	......	6	1— 4	3.3
Bartlett	6	1—13	4.8	87	23— 0	4.2	69	17— 4	4.0	5	1— 2	3.6	......	....	......	15	5— 0	5.3
Keiffer	402	91—13	3.7	9	3— 1	5.4	122	40—13	5.4	67	20—10	4.9	79	27—10	5.6	178	57— 1	5.1
Total	418	95—13	3.7	115	30— 2	4.2	255	73— 7	4.6	162	49— 4	4.9	237	77— 0	5.2	381	118— 0	5.9
Total per plot	533	125—15	3.8	......	....	......	417	122—11	4.7	......	....	......	618	195— 0	5.0	......	....	......
Total per plot, 1900	81	9—14	5.1	......	....	......	168	49—10	4.7	......	....	......	86	24—15	4.6	......	....	......
Total per plot, 1901	69	19—10	4.6	......	....	......	39	11— 1	4.5	......	....	......	67	21— 8	5.1	......	....	......
Total per plot, 1902	246	61—13	4.0	......	....	......	120	39—15	5.3	......	....	......	150	60— 4	6.4	......	....	......
Average, four crops	220	54— 5	3.9	......	....	......	186	55—13	4.8	......	....	......	230	75— 7	5.2	......	....	......

TABLE 18—Continued.

Dwarf Pears—Fertilizer Plots.

VARIETY.	UNIRRIGATED.																	
	PLOT 4.						PLOT 5.						PLOT 6.					
	TREE 1.			TREE 2.			TREE 1.			TREE 2.			TREE 1.			TREE 2.		
	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.
Dwarfs.		lbs. oz.	oz.		lbs. oz.	oz		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.
Lawrence	86	11— 1	4.9	.....	.....	.....	20	5— 9	4.5	24	6— 7	4.3	37	9—10	4.2	19	5— 6	4.5
Bartlett	37	5—12	2.5	.....	.....	.....	100	34— 4	5.5	41	13— 7	5.2	.....	.....	.....	1	0— 7	7.0
Dwarfs by Cutting.																		
Lawrence	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	6	1— 8	4.0	1	0— 5	5.0
Bartlett	61	16— 4	4.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	101	30—15	4.9	9	2— 8	4.4
Keiffer	65	18— 9	4.6	36	8— 3	3.6	45	11— 4	4.0	160	43—11	4.4	31	9— 5	4.8	64	18— 7	4.6
Total	199	51—10	4.2	36	8— 3	3.6	165	51— 1	5.0	225	63— 9	4.5	175	51— 6	4.7	94	27— 1	4.6
Totals per plot	235	59—13	4.1	.....	.....	.....	390	114—10	4.7	.....	.....	.....	269	78— 7	4.7	.....	.....	.....
Total per plot, 1900	132	39— 7	4.8	.....	.....	.....	109	28—12	4.2	.....	.....	.....	16	3—12	3.8	.....	.....	.....
Total per plot, 1901	56	18— 4	5.2	.....	.....	.....	53	16—12	5.1	.....	.....	.....	22	7— 6	5.4	.....	.....	.....
Total per plot, 1902	100	32— 4	5.2	.....	.....	.....	108	33— 2	4.9	.....	.....	.....	146	49— 4	5.4	.....	.....	.....
Average, four crops	131	37— 7	4.6	.....	.....	.....	165	48— 5	4.7	.....	.....	.....	113	34—11	4.9	.....	.....	.....

Varieties.

Table 19 contains the records of the varieties fruiting in 1903, and the number of years since setting in which fruit has been produced, with the average annual yield. Similar data is given for varieties in the plot work for comparison.

In the dwarf sorts proper, all except Clapp's Favorite and Howell have fruited four seasons. White Doyennè has given the largest average yield, with Angouleme or Duchesse second of those fruiting four seasons.

Of the dwarfs by cutting, Clairgeau, Le Conte, Bartlett and Keiffer, have fruited four seasons. Keiffer and Le Conte give by far the largest yields.

STANDARD PEARS.

The records of the orchard appear in Tables 20 and 21. Table 20 contains detailed records of plot work for 1903, and totals by plots for previous years of fruiting. Table 21 contains records of varieties, with average yields to date and number of years producing more or less fruit.

The relation between plots are the same in 1903, and in the average of the four crops. Plot 2 receiving the general mixture of fertilizer, has the highest yields, with plot 3, the mixture with nitrate, lowest.

The severe winds of September 16th blew a great deal of the fruit from the trees. It is interesting to note the percentage of the Keiffer's that was picked from the ground after this blow. Plot 1, 41.2 per cent., plot 2, 68. per cent. and plot 3, 72.7 per cent.

It seems to be a question of amount of fruit produced by tree, rather than any relation of method of fertilizing and ability of tree to hold fruit.

TABLE 19.

Dwarf Pears—Varieties.

VARIETY.	Date marketable.	YIELD, 1903.						TREES SET SPRING 1896. AVERAGE YIELD PER TREE TO DATE, INCLUDING VARIETIES IN THE PERMANENT PLOTS FOR COMPARISON.			Number of years bearing more or less fruit.
		TREE 1.			TREE 2.						
		Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	
Dwarfs.			lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.	
Margaret	Aug. 25.	5	1—6	4.4	15	3—13	4.1	18	3—11	3.3	4
Clapp's Favorite	Aug. 8.	59	23—5	6.3	224	52—11	3.8	49	13—4	4.3	3
Howell	Sept. 4.	39	12—8	5.1	42	14—2	5.4	22	6—7	4.7	3
Angouleme	Sept. 14.	100	46—15	7.5	59	31—13	8.6	25	12—8	8.0	4
White Doyenné	Sept. 4.	159	41—8	4.2	193	50—0	4.1	53	14—2	4.3	4
Seckel	Sept. 16.	28	5—14	3.4	69	14—5	3.3	19	3—13	3.2	4
Lawrence	......	......	......	......	......	......	......	16	4—3	4.2	4
Bartlett	......	......	......	......	......	......	......	26	8—8	5.0	4
Dwarfs by Cutting.											
Anjou	Sept. 17.	3	1—12	9.3	......	......	......	3	1—12	9.3	1
Le Conte	Sept. 29.	170	58—5	7.1	36	8—14	3.9	43	14—8	5.4	4
Clairgeau	Sept. 14.	......	......	......	29	16—15	9.3	10	5—9	8.9	4
Clapp's Favorite	Aug. 8.	4	1—11	6.8	......	......	......	4	1—11	6.8	1
Seckel	......	......	......	......	......	......	......	......	......	......	......
Sheldon	......	......	......	......	......	......	......	......	......	......	......
Belle Lucretive	Aug. 29.	......	......	......	54	11—15	3.5	29	7—7	4.1	3
Margaret	......	......	......	......	......	......	......	2	0—11	5.5	1
Howell	Sept. 4.	6	1—8	4.0	......	......	......	7	1—6	3.1	2
Lawrence	......	......	......	......	......	......	......	4	1—5	5.3	3
Bartlett	......	......	......	......	......	......	......	24	6—11	4.5	4
Keiffer	......	......	......	......	......	......	......	55	16—7	4.8	4

TABLE 20.

Standard Pears—Fertilizer Plots.

VARIETY.	PLOT 1.						PLOT 2.						PLOT 3.					
	TREE 1.			TREE 2.			TREE 1.			TREE 2.			TREE 1.			TREE 2.		
	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.
		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.
Lawrence	12	3— 2	4.2	......	....	......	3	0—13	4.3	......	....	......	......	....	......	14	4— 6	5.0
Bartlett	......	....	......	15	3—12	4.0	78	30— 9	6.3	98	34— 5	5.6	66	21— 3	5.1	162	53—12	5.3
Keiffer	497	110—11	3.6	813	165— 7	3.3	601	180— 9	4.8	684	199— 7	4.7	49	16— 9	5.4	255	77—10	4.9
Clapp's Favorite	......	....	......	9	3—10	6.4	......	....	......	......	....	......	4	2—11	10.8	5	2— 3	7.0
Seckel	7	1— 5	3.0	33	7— 7	3.6	......	....	......	15	1— 9	1.7	8	1— 2	2 3	......	....	......
Total	516	115— 2	3.6	870	180— 4	3.3	682	211—15	5.0	797	235— 5	4.7	127	41— 9	5.2	436	137—15	5.1
Totals per plot	1386	295— 6	3.4	......	....	......	1479	447— 4	4.8	......	....	......	563	179— 8	5.1	......	....	......
Totals per plot, 1900	163	51— 6	5.0	......	....	......	158	51—14	5.3	......	....	......	121	38—10	5.1	......	....	......
Totals per plot, 1901	230	84—11	5.9	......	....	......	179	60— 8	6.1	......	....	......	243	89—14	5.9	......	....	......
Totals per plot, 1902	585	155— 7	4.3	......	....	......	579	211— 4	5.8	......	....	......	351	123—10	5.9	......	....	......
Average, four crops	591	146—12	4.0	......	....	......	599	192—12	5.1	......	....	......	320	109— 3	5.5	......	....	......

TABLE 21.

Standard Pears—Varieties.

VARIETY.	Date marketable.	YIELD, 1903. TREE 1. Number of fruits.	TREE 1. Weight.	TREE 1. Average per fruit.	TREE 2. Number of fruits.	TREE 2. Weight.	TREE 2. Average per fruit.	TREES SET SPRING 1896. AVERAGE YIELD PER TREE TO DATE, INCLUDING VARIETIES IN PERMANENT PLOTS FOR COMPARISON. Number of fruits.	Weight.	Average per fruit.	Number years bearing more or less fruit.
			lbs. oz.	oz.		lbs. oz.	oz.		lbs. oz.	oz.	
Angel	Aug. 21.	172	44–2	4.1	31	10–11	5.5	34	10–5	4.9	4
Dorsett	Sept. 18.	4	1–10	6.5	68	20–10	4.9	21	6–12	5.1	3
Flemish Beauty	Sept. 18.	2	1–2	9.0	......	....	......	2	1–2	9.0	1
Giffard	....	......	....	......	......	....	......	....	....	....	......
Idaho	Original trees blighted and reset, one of them twice.										
Koonce	Aug. 5.	2	0–8	4.0	19	3–12	3.2	10	2–3	3.5	2
Lady Clapp	Aug. 29.	45	16–7	5.8	......	....	......	19	6–15	5.8	3
P. Barry	Sept. 30.	......	....	......	96	21–13	3.6	29	8–2	4.5	4
Winter Nelis	Sept. 18.	26	7–5	4.5	93	16–10	2.9	24	4–15	3.3	4
Bartlett, Stringfellow set.	Aug. 21.	27	5–5	3.1	......	....	......	27	5–5	3.1	1
Keiffer, Stringfellow set	Sept. 18.	40	12–8	5.0	5	1–7	4.6	21	6–11	5.1	2
Lawrenee	....	......	....	......	......	....	......	8	2–3	4.4	4
Bartlett	....	......	....	......	......	....	......	37	13–2	5.7	4
Keiffer	....	......	....	......	......	....	......	224	66–12	4.8	4
Clapps' Favorite	....	......	....	......	......	....	......	6	3–8	8.5	1
Sheldon	....	......	....	......	......	....	......	6	2–15	7.8	1
Seckel	....	......	....	......	......	....	......	12	2–5	3.1	2

Six of the fifteen varieties have fruited four seasons. Of the six varieties set according to the Stringfellow plan, two only have fruited. Bartlett once and Keiffer two seasons.

The Keiffer trees, in plot work, have averaged five times as productive as any other variety. Bartlett is next in order of productiveness.

PEACHES.

In spite of the unfavorable spring, the trees set and matured a fair crop of fruit. A larger proportion than usual graded as culls; the excessive moisture causing much of the fruit to crack.

The records for each tree in crop of 1903 is given in Table 22. Also records by plots for crop of 1903, and the average of the five crops taken from the orchard.

The yields per plot are calculated for a full plot of twelve trees. Wherever a tree is out, the yield of the tree remaining is doubled in getting the total for plot.

The orchard is so arranged that we have a comparison with six varieties only in the first three plots. The yields from these plots in 1903 are the reverse of numbering; plot 3 has the highest yield, 2 and 1, in order. The relations are the same in the average of the five crops, excepting that plot 2 is lower in yield than one.

A study of the percentages of marketable fruit shows that the first plot carries the greatest proportion, and the third the lowest, while plot 2 has the largest percentage of fruit, grading No. 1. In total amount of marketable fruit, and of fruit grading firsts, however, plot 3 leads. In average size of fruit, plot 3 gives the largest, with plot 1 lowest.

For comparing the four plots, we have the yields of five varieties. Stevens' Rareripe being excluded from the first three, and is not set in the fourth plot.

In total yields, plot 3 is first and 4 second, in order, and plot 1 lowest. The same relations hold in average of the five crops.

In proportion of marketable fruit, plot 1 gives the highest percentage, with plot 4 second and plot 3 lowest. In total amount of marketable fruit, however, plot 3 gives by far the largest in crop of 1903. In the average crop, however, the total quantity of marketable fruit produced on plot 4 is slightly larger than that given on plot 3.

In average size of marketable fruit produced, plot 4 leads, with 3 second and with plot 1 in crop of 1903, and plot 2 in average crop, least in average weight per fruit.

TABLE 22.

Peaches—Fertilizer Plot.

VARIETY.	TOTAL YIELDS. TREE 1. Number of fruits.	Weight.	Per cent. No. 1 fruit.	Average weight per fruit.	Per cent. No. 2 fruit.	Average weight per fruit.	Number of thinnings.	TREE 2. Number of fruits.	Weight.	Per cent. No. 1 fruit.	Average weight per fruit.	Per cent. No. 2 fruit	Average weight per fruit.	Number of thinnings.
Plot 1.		lbs. oz.		oz.		oz.			lbs. oz.		oz.		oz	
Susquehanna	2	0— 6	83.0	5.0	....	....	....	....	....	....	....	....	....	....
Stevens' Rareripe	334	31— 6	14.3	2.2	72.3	1.5	....	539	56— 4	13.9	2.3	74.7	1.7	....
Elberta	79	15— 7	61.9	3.5	19.3	2.7	....	....	....	....	....	....	....	....
Crawford's Late	63	10—13	65.9	3.1	23.7	2.3	....	....	....	....	....	....	....	....
Reeve's Favorite	94	13—13	33.0	2.7	55.2	2.2	....	....	....	....	....	....	....	....
Old Mixon	105	14—15	45.2	2.8	27.6	2.0	....	145	22— 4	43.0	3.0	21.9	2.2	....
Totals	677	86—12	37.8	2.9	44.6	1.7	....	684	78— 8	22.1	2.6	59.7	1.7	....
Totals per plot	1,597	205— 5	34.8	2.9	47.5	1.8	....	....	....	....	....	....	....	....
Average totals, five crops	4,400	531— 8	42.9	2.9	50.4	1.6	3,712	....	....	....	....	....	....	....
Totals, excluding Stevens' Rareripe	724	117—11	50.2	3.1	27.8	2.2	....	....	....	....	....	....	....	....
Average totals, five crops	3,029	411—15	49.6	2.9	44.6	1.8	2,722	....	....	....	....	....	....	....

TABLE 22—Continued.

Peaches—Fertilizer Plot.

VARIETY.	TOTAL YIELDS. TREE 1. Number of fruits.	Weight.	Per cent. No. 1 fruit.	Average weight per fruit.	Per cent. No 2 fruit.	Average weight per fruit.	Number of thinnings.	TREE 2. Number of fruits.	Weight.	Per cent. No. 1 fruit.	Average weight per fruit.	Per cent. No. 2 fruit.	Average weight per fruit.	Number of thinnings.
Plot 2.		lbs. oz.		oz.		oz.			lbs. oz.		oz.		oz.	
Susquehanna	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Stevens' Rareripe	325	32—10	15.3	2.2	58.4	1.6	....	744	71—15	23.3	2.4	54.5	1.5	....
Elberta	64	8—10	48.6	2.2	13.0	2.0	....	106	16—5	38.7	3.1	15.7	2.3	....
Crawford's Late	36	7—3	65.2	3.6	1.7	2.0	....	128	20—14	46.4	3.2	16.2	2.3	....
Reeve's Favorite	....	....	....	....	....	....	....	79	19—9	86.9	4.2	6.7	3.0	....
Old Mixon	441	70—15	47.0	3.0	22.1	2.2	....	515	86—2	51.3	3.2	14.4	2.2	....
Totals	866	119—6	39.6	2.8	30.2	1.9	....	1,572	214—13	43.8	3.1	27.4	1.6	....
Totals per plot	2,517	353—12	44.8	3.1	27.2	1.7	....	....	....	....	....	....	....	....
Average totals, five crops	4,026	511—15	45.2	2.6	46.5	1.8	2,575	....	....	....	....	....	....	....
Totals, excluding Stevens' Rareripe	1,448	219—3	54.8	3.3	15.2	2.2	....	....	....	....	....	....	....	....
Average totals, five crops	2,993	414—12	50.0	2.7	42.2	1.9	1,981	....	....	....	....	....	....	....

TABLE 22—Continued.

Peaches—Fertilizer Plot.

VARIETY.	Tree 1. Number of fruits.	Tree 1. Weight.	Tree 1. Per cent. No. 1 fruit.	Tree 1. Average weight per fruit.	Tree 1. Per cent. No. 2 fruit.	Tree 1. Average weight per fruit.	Tree 1. Number of thinnings.	Tree 2. Number of fruits.	Tree 2. Weight.	Tree 2. Per cent. No. 1 fruit.	Tree 2. Average weight per fruit.	Tree 2. Per cent. No. 2 fruit.	Tree 2. Average weight per fruit.	Tree 2. Number of thinnings.
Plot 3.		lbs. oz.		oz.		oz.			lbs. oz.		oz.		oz.	
Susquehanna	....	....	....	....	....	....	....	7	0—10	....	....	70.0	1.4	....
Stevens' Rareripe	444	42— 3	20.7	2.4	54.2	1.7	....	446	53— 9	30.8	2.5	55.5	1.8	....
Elberta	414	74—13	37.5	3.6	16.8	2.5	....	718	114—12	47.1	3.4	36.5	2.2	....
Crawford's Late	224	34— 7	40.5	3.0	50.5	2.3	....	54	12— 0	78.6	3.9	9.4	2.6	....
Reeve's Favorite	87	21— 9	80.9	4.3	11.6	3.1	....	75	20— 0	75.6	4.7	1.9	3.0	....
Old Mixon	390	53—13	24.6	2.9	21.1	2.1	....	695	98—12	29.5	3.0	15.8	2.0	....
Totals	1,559	226—13	35.9	3.3	29.4	2.1	....	1,995	299—11	41.5	3.3	29.7	2.0	....
Totals per plot	3,554	526— 8	39.1	3.3	29.6	2.0	....	....	....	....	....	....	....	....
Average totals, five crops	4,471	629— 2	44.6	3.0	44.4	2.0	3,182	....	....	....	....	....	....	....
Totals, excluding Stevens' Rareripe	2,664	430—12	41.9	3.4	24.0	2.2	....	....	....	....	....	....	....	....
Average totals, five crops	3,292	485—11	50.7	3.0	38.8	2.0	2,165	....	....	....	....	....	....	....

TABLE 22—Continued.

Peaches—Fertilizer Plot.

VARIETY.	TOTAL YIELDS.													
	TREE 1.							TREE 2.						
	Number of fruits.	Weight.	Per cent. No. 1 fruit.	Average weight per fruit.	Per cent. No. 2 fruit.	Average weight per fruit.	Number of thinnings.	Number of fruits.	Weight.	Per cent. No. 1 fruit.	Average weight per fruit.	Per cent. No. 2 fruit.	Average weight per fruit.	Number of thinnings.
Plot 4.		lbs. oz.		oz.		oz.			lbs. oz.		oz.		oz.	
Susquehanna	19	4— 0	17.2	5.5	....	....	....	8	1— 2	22.2	4.0	38.9	2.3	....
Stevens' Rareripe	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Elberta	502	94— 2	61.7	3.7	21.6	2.3	....	204	34— 5	48.5	3.2	15.1	2.2	....
Crawford's Late	171	30—15	49.1	3.8	23.0	2.5	....	151	30—11	55.6	3.9	12.2	2.8	....
Reeve's Favorite	40	10—12	82.6	4.6	....	....	....	3	0—13	38.5	5.0	....	....	....
Old Mixon	339	56— 7	39.6	3.3	14.4	2.1	....	189	30— 7	51.7	3.3	30.6	2.1	....
Totals	1,071	196— 4	53.6	3.7	18.1	2.3	....	555	97— 6	51.3	3.5	19.2	2.2	....
Totals per plot	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Average totals, five crops	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Totals, excluding Stevens' Rareripe	1,626	293—10	52.9	3.6	18.5	2.3	....	....	....	....	....	....	....	....
Average totals, five crops	2,725	462—14	64.2	3.3	29.3	2.1	2,147	....	....	....	....	....	....	....

TABLE 23.

Peaches—Varieties.

VARIETY.	Date marketable.	TREE 1. Number of fruits.	TREE 1. Weight.	TREE 1. Per cent. No. 1 fruits.	TREE 1. Average weight per fruit.	TREE 1. Number of fruits.	TREE 1. Per cent. No. 2 fruits.	TREE 2. Average weight per fruit.	TREE 2. Weight.	TREE 2. Per cent. No. 1 fruits.	TREE 2. Average weight per fruit.	TREE 2. Per cent. No. 2 fruits.	TREE 2. Average weight per fruit.	Average annual yield per tree, five crops.
			lbs. oz.		oz.		oz.		lbs. oz.		oz.		oz.	lbs. oz.
Champion	Aug. 17.	861	142–0	58.8	3.5	29.9	2.2	1,036	174–5	58.8	3.4	23.4	2.3	111–4
Crosby	Sept. 7.	365	46–11	21.6	3.0	33.1	2.1	408	62–15	48.5	3.2	32.0	2.2	64–0
Sneed	July 7.	305	28–1	....	....	67.0	1.7	....	....	....	....	....	....	*17–6
Surpasse	Aug. 17.	129	28–1	83.3	3.7	8.2	2.8	78	10–3	44.2	2.7	46.0	1.9	*30–4
Wards' Late	Sept. 17.	292	30–4	21.7	2.4	60.1	1.6	266	27–15	15.7	2.4	66.9	1.6	70–10

* Four crops only.

The early application of nitrate of soda upon plots 3 and 4 has a very marked effect upon the appearance of foliage and growth of trees—a difference noticeable throughout the season. This difference extends farther than appearance, for these plots have given the largest yields both in crop of 1903 and the average of the five crops. The mixture of potash and acid phosphate, 1 to 2, respectively, as used upon plot 4, is not as effective in production of fruit as the general mixture of equal parts of bone, potash and acid phosphate, as used upon plot 3.

Varieties.

Table 23 gives yields of those varieties fruiting this season, with their average yields to date.

Sneed is an extremely early sort, not productive and small in size. Champion, a medium early sort, white and semi-cling in character, is very productive of good-sized fruits.

APPLES.

This is the second year only of fruiting; many of the varieties carried a good crop, others little or none at all. The results of the year, both upon plots and with varieties, are given in Table 24.

Of the six varieties in plots, Gravenstein, only, bore no fruit, while Jonathan and Smith's Cider carried a full crop upon most trees. Plot 1 has never received any fertilizer, and has not been cropped. Plots 2 and 3 receive 500 pounds per acre each of the general fruit tree mixture, and have been cropped with vegetables each year since setting. The yields of plot 2 have been the largest each year, while that from plot 3 is lowest in order.

Of the varieties, Ben Davis is the only sort carrying anything like a crop. Stump is the only variety set that has never given any fruit. It is very upright in habit of growing, and presents a problem each season in pruning to make a decent tree.

TABLE 24.

Apples—Fertilizer Plots and Varieties.

VARIETY.	PLOT 1.						PLOT 2.						PLOT 3.					
	TREE 1.			TREE 2.			TREE 1.			TREE 2.			TREE 1.			TREE 2.		
	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.	Number of fruits.	Weight.	Average per fruit.
		lbs. oz.	oz		lbs. oz	oz.		lbs oz.	oz.		lbs. oz.	oz		lbs. oz.	oz.		lbs. oz.	oz.
Baldwin	...	...	...	280	87— 0	5.0	132	35— 3	4.3	97	26— 9	4.4	39	13— 9	5.6	2	0— 6	3.0
Jonathan	...	...	...	341	70— 4	3.3	311	63—15	3.3	389	74— 7	3.1	...	...	...	108	25— 5	3.8
King Tompkins	11	4— 7	6.5	4	1— 2	4.5	22	7— 4	5.3	17	5— 8	5.2	29	10— 1	5.6	1	0— 8	8.0
Oldenburgh	30	6— 2	3.3	22	4— 0	4.9	65	12—11	3.1	44	8— 8	2.7	9	2— 2	3.8	32	6— 6	3.2
Smith's Cider	354	82— 4	3.7	219	44— 9	3.3	326	70— 1	3.4	157	33— 0	3.4	11	2— 4	3.3	111	25— 8	3.7
Total	395	92—13	3.8	866	206—15	3.8	856	189— 2	3.5	704	148— 0	3.4	88	28— 0	5.1	254	58— 1	3.7
Totals per plot	1,261	299—12	3.8	...	...	...	1,560	337— 2	3.5	...	...	...	342	86— 1	4.0	...	...	...
Totals per plot, 1902	265	55— 7	3.3	...	...	...	374	69—13	3.0	...	...	...	87	15— 0	2.8	...	...	...
Varieties.																		
Barry	...	10— 4	...	...	5—15	...	...	...	...	...	...	...	...	...	...	...	...	...
Ben Davis	334	73— 4	3.5	308	58— 8	3.0	...	...	...	...	...	...	...	...	...	...	...	...
Monmouth Pippin	14	3— 3	3.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Williams' Favorite	21	3—15	3.0	8	1—12	3.5	...	...	...	...	...	...	...	...	...	...	...	...
Yellow Transparent	46	7—13	2.7	27	5— 2	3.0	...	...	...	...	...	...	...	...	...	...	...	...

REPORT OF THE DAIRY HUSBANDMAN.

DAIRY HUSBANDRY.

For the year ending November 30th, 1903, the work in the Department of Dairy Husbandry may be briefly described as follows:

The study of forage crops, including crop rotations, cost and yield of forage, and new varieties.

Nitrate of soda as a top-dressing for rye, wheat, grass, "cow peas and millet" and barley, was made a subject for study, and its effect upon the yield and value of the crop noted.

The seeding of grass on sod was given a trial in August, 1902, and notes on the first crop are reported.

Inoculation experiments with alfalfa were conducted during the summer, and the results of the first season's work are given.

Daily records have been kept of the dairy herd, and the milk of each animal analyzed semi-monthly, the results of which are reported. A study of the comparative value of forage crops and silage for dairy cows has been continued for seven years, and the results are herein reported. A study of the dairy business in relation to soil exhaustion has been continued for seven years, and the results showing the gains and losses to the farm, are given.

Further experience in the use of the "Schmidt Treatment" as a cure for milk fever are noted. Only one case, however, occurred this year.

The production of milk for the retail trade, sale and wastes in handling and delivery.

Feeding experiments with alfalfa hay, cow pea hay, soy bean silage, cottonseed meal, wheat bran and dried brewers' grains, occupied considerable time during the winter, and the results are given in detail in this report.

Soiling Crops, 1903.

The early part of the season of 1903 was characterized by a severe drought. Less than one-half inch of rain fell between April 15th and June 6th. The precipitation during the remainder of June and the months of July and August was abundant, but the temperature was too low for rapid growth. In spite of these unfavorable conditions, some fields of wheat, millet and alfalfa yielded heavily. Twelve kinds of forage were grown, alfalfa proving most valuable of them on the basis of cost of production, yield and composition. The herd, including young stock, was equivalent to fifty full-grown animals. The arrangement of forage crops shown in Table I. furnish a continuous supply from May 1st until October 20th. About one and one-half tons of green forage were cut each morning to supply the herd for the day. This was fed to the cows in a two-acre field, into which they were turned every morning for exercise. The amount of forage fed varied according to the kind of forage and the requirements of the animal. The average amount per day was sixty pounds per cow. In addition to the roughage used in summer, the cows received a feed ration averaging 6.6 pounds per day, of wheat bran, dried brewers' grains, corn meal and cottonseed meal mixed in proportion to make a ration having a nutritive ratio of about 1.6.

A careful record was kept of the cost of producing each crop, time of cutting and seeding and the yield per acre. Data concerning crops grown in 1903 are contained in the following table:

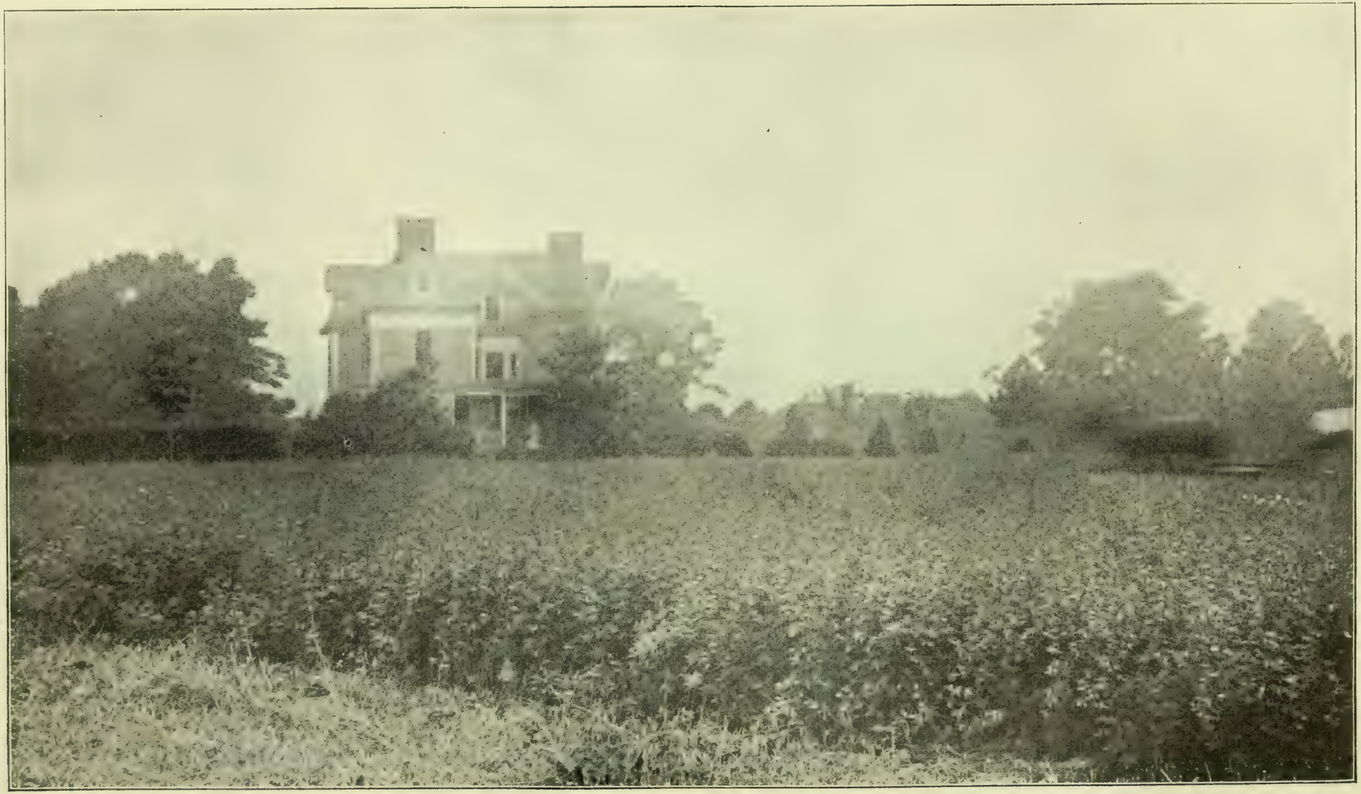


Fig. 1.

Alfalfa. Season 1903.

Fig. 2.

A bunch of Alfalfa Plants five years old.

TABLE I.

Cost and Yield of Soiling Crops.

Number of acres.	KIND.	Date of seeding.	Seed used—bushels.	COST OF— Labor.	Seed.	Fertilizer.	Period of cutting and feeding.	Yield—tons.	Total cost.
2	Rye	Aug. 19, 1902.	3½	$3 90	$2 44	....	May 1- 5	8.48	$6 34
2	Rye	Aug. 27, 1902.	4	2 70	2 24	$4 50	" 5-12	11.70	9 44
2	Wheat	Oct. 11, 1902.	3½	6 60	2 98	....	" 12-23	20.68	9 58
2	Wheat.	Oct. 14, 1902.	4	5 40	3 40	3 37	" 23 to June 1	12.20	12 17
2	Crimson Clover	Sept. 5, 1902.	½	5 40	2 25	3 80	June 1 -5	8.50	11 45
3	Crimson Clover (seeded in corn)	Aug. 21, 1902.	3/8	45	2 70	....	" 5-10	9.00	3 15
1.87	Alfalfa (first cutting)	May 28, 1901.	1	....	....	5 53	" 10-14	6.90	5 53
3	Peas and Oats	Mar. 28, 1903.	{ 5¼ 6 }	10 85	12 30	8 70	" 14-25	16.44	31 35
3	Peas and Oats	Apr. 20, 1903.	{ 4½ 6 }	9 00	11 10	8 70	" 25 to July 7	20.20	28 80
1	Mixed Grasses	Sept. —, 1902.	....	....	....	....	July 7-11	6.00	....
1.87	Alfalfa (second cutting)	....	....	....	....	....	" 11-18	10.75	....
1	Barnyard Millet	Apr. 24, 1903.	½	1 80	1 62	2 96	" 18-25	13.60	6 38
2	Vetch and Oats	May 11, 1903.	{ 1 4 }	6 00	5 60	4 84	" 25 to Aug. 1	10.20	16 44
1	Mixed Grasses	....	....	....	....	....	Aug. 1- 5	6.20	....
2	Cow Peas and Kaffir Corn	June 13, 1903.	{ 2 1 }	6 60	5 80	5 14	" 5- 9	7.60	17 54
2	Cow Peas and Millet	June 17, 1903.	{ 2 1 }	6 00	8 15	4 52	" 9-19	19.10	18 67

TABLE I.—Continued.

Cost and Yield of Soiling Crops.

Number of acres.	KIND.	Date of seeding.	Seed used—bushels.	COST OF— Labor.	COST OF— Seed.	COST OF— Fertilizer.	Period of cutting and feeding.	Yield—tons.	Total cost.
2	Barnyard Millet	June 18, 1903.	1¼	$4 80	$3 96	$4 64	Aug. 19–22	4.75	$13 40
1.87	Alfalfa (third cutting)	....	....	....	....	....	" 22–27	8.00	....
10	Mixed Grasses (second crop)	Aug. —, 1902.	....	....	....	....	" 27 to Sept. 7	20.08	....
3	Corn Fodder	May 23, 1903.	¾	12 60	75	9 51	Sept. 7–24	24.00	22 86
1	Corn Fodder	May 27, 1903.	¼	4 20	25	3 76	" 24–27	5.73	8 21
1	Corn Fodder	June 27, 1903.	⅓	4 20	35	93	" 27–30	7.00	5 48
1.87	Alfalfa (fourth cutting)	....	....	....	....	....	Oct. 1– 3	4.05	....
2	Barley	July 28, 1903.	4	6 60	5 00	6 00	" 3– 7	7.30	17 60
1	Corn Fodder	May 27, 1903.	¼	4 20	25	3 76	" 7–10	6.00	8 21
2	Barley	Aug. 13, 1903.	3½	7 20	4 38	5 60	" 10–14	6.80	17 18
1	Cow Peas	July 1, 1903.	⅔	4 00	1 75	2 02	" 14–17	6.04	7 77
1	Sweet Corn	July 1, 1903.	⅓	3 75	50	2 32	" 17–20	5.00	6 57
	Total	....	....	....	....	....	....	292.20	

Fig. 3.
A crop of Crimson Clover.

Fig. 5.
A bunch of Field Peas. Unlimed and lightly manured, showing absence of tubercles.

Fig. 6.
A bunch of Field Peas. Limed and well manured, showing abundance of tubercles on the roots

General Remarks Concerning Crops.

Rye and Wheat.—As in previous years, the cutting of rye began May 1st. Four acres were grown for soiling this season. The yield ranged from 4.24 to 6.70 tons per acre. While the yields were not large, the forage supplied food for the herd at a time when nothing else was available and the land was immediately seeded to other crops.

Two acres of wheat top-dressed with barnyard manure in the spring, yielded a total of 20.68 tons. Another field of two acres yielded 12.2 tons. Wheat follows rye in close succession, and is greatly relished by dairy animals.

Alfalfa.—The five-year experiment with one acre of alfalfa closed last season, and as stated in the annual report of the Station for 1902, the average yield of green forage per year, including the year it was seeded, was 19.32 tons. The largest yield, namely, 26.6 tons, was produced the third year. The plot was pulverized with a disk-harrow this spring to a depth of six inches, and seeded to Barnyard Millet, April 24th. This crop was harvested in July, when the plot was re-seeded with alfalfa.

Another plot of alfalfa consisting of one acre, seeded May 23d, 1901, yielded 11.36 tons this season. A third plot of .87 acre yielded from four cuttings this season at the rate of 21.36 tons per acre. Some new plots seeded this fall look very promising at the present time (October 15th), and it is believed that the fall season will prove a better time to seed than any other for the reason that very few weeds appear, and further, no time is lost, as the ground can be occupied all summer with other crops.

Crimson Clover.—A very valuable plant for early forage. It may be sown in corn at the time of the last cultivation (July), as a catch-crop and what is not needed for forage can be easily turned under for green manure. The crop proved particularly valuable this season on account of the drouth. While the yields were not large, a considerable area was cut, supplying an abundance of forage until the next crop was available. Crimson clover hay is also relished by dairy animals, and makes a valuable food for winter.

Peas and Oats.—A crop now considered almost a necessity by dairymen who practice the soiling system. When sown the first week in April it supplies the best of forage during the month of June. We have found by experience that there are certain conditions which are particularly favorable to the growth of this crop, and therefore pay well to supply. Peas and oats will not do their best where the soil is acid, hence it is desirable to give the soil a dressing of lime. Again, we have found that well-rotted barnyard manure, supplied in abundance, furnishes the best of conditions for the development of bacteria which enable the field peas to make use of the free nitrogen of the air. The manure furnishes at the same time soluble plant-food, so important to all crops maturing early in the season. Figs. 5 and 7 show field peas grown under unfavorable and favorable conditions. The root development of these plants is also shown in Figs. 6 and 8.

Vetch and Oats.—A crop similar to peas and oats, but which has proved superior for midsummer feeding, as vetch grows better than field peas in hot weather. This crop is eaten greedily by animals, is rich in nitrogenous compounds and has proved valuable in the forage rotation. A photograph of the field is shown in Fig. 9.

Millets.—This class of plants proves very valuable in short rotations. The Barnyard variety has proved one of the most valuable in past years, owing to its rapid growth and comparatively high content of dry matter. Fig. 10 shows a plot of one acre grown this season, that yielded 13.6 tons.

Experiments with Different Varieties of Millet.

As this crop is of general interest to many dairy farmers, it was thought that a comparative test of the principal varieties advertised by seedsmen would be of value. Such a test was arranged this season, and nine varieties were secured. The seed was sown July 14th in small plots, the arrangement of which is shown in Figs. 9, 10 and 11. The seed came up well and all varieties made rapid growth at the start. The following tabulation shows the height, time of heading and yield of each variety:

Fig. 9.
Varieties of Millet.

Fig. 10.
Varieties of Millet.

Fig. 11.
Varieties of Millet.

TABLE II.

VARIETY.	Cost of seed per pound.	Date of seeding.	Date heads appeared.	Height at harvest, October 14th.	Yield per plot.	Relative yield per acre.
	cts.			ft.	lbs.	tons.
White French	.15	July 14.	Aug. 20.	1.8	1.0	1.74
Hungarian	.03	" 14.	" 20.	2.4	2.0	3.48
Red Siberian	.10	" 14.	" 25.	2.4	2.0	3.48
Golden	.10	" 14.	" 25.	2.7	2.5	4.35
German	.03	" 14.	" 25.	2.5	3.0	5.22
Barnyard	.09	" 14.	" 30.	2.8	8.5	14.79
Giant	.40	" 14.	Sept. 5.	2.8	9.5	16.53
Pencilaria	.75	" 14.	" 15.	5.0	14.0	24.36
Pearl	.10	" 14.	" 15.	4.5	17.0	29.58

The varieties in the tabulation are arranged in the order in which the first heads appeared, or their time of maturity. It is noticeable that this order corresponds exactly with the yield of the different varieties. For example, the White French, which began to show heads August 20th, gave the lowest yield of any variety, while the Pearl, which was one of the latest varieties, produced the highest yield. The tabulation indicates, therefore, that there is but little growth after the plants begin to mature, hence the best yields are obtained from the later varieties. The Giant and Barnyard varieties, proved to be practically the same. This was also true with the Pencilaria and Pearl varieties. Seedsmen sell the same variety under different names with the pretense of introducing a new plant, and charge many times the price of the original. Farmers should take this precaution when buying new varieties. In considering the results in the above tabulation, it is believed that the first five varieties, namely, White French, Hungarian, Red Siberian, Golden and German are not as profitable as the Barnyard (Giant) and Pearl (Pencilaria), where the object is to grow the largest amount of forage possible. Some of these varieties may, however, be better adapted for hay. Of the two other distinct varieties, namely, Barnyard and Pearl, the Barnyard

has given better results as an all-around crop for the reason that it contains a higher percentage of dry matter and produces smaller and more palatable plants. Figs. 9, 10 and 11 show the different varieties just before they were harvested.

Cow Peas.—These plants are also of considerable interest to dairymen for forage or green manure, and in order to throw some light upon the adaptability of some of the manifold varieties for certain specific purposes, a test was made including thirteen of the principal kinds. Plots of one-twentieth of an acre were seeded with each variety July 1st. The seed was placed in drills two and one-half feet apart and at the rate of twenty quarts per acre. The following tabulation shows the varieties used, their characteristics and yields:

Fig. 12.
Varieties of Cow Peas.

Fig. 13.
Varieties of Cow Peas.

Fig. 14.
Varieties of Cow Peas

TABLE III.

VARIETY.	Area.	Date of seeding.	Notes—Fifty days after seeding.	Notes—Eighty-four days after seeding.	Matured.	Yield per plot.	Estimated yield per acre.
						lbs.	tons.
Black Eye	$\frac{1}{20}$ acre.	July 1.	Trailing—vines 3 to 4 ft	Vines 5 to 6 ft —pods formed	Early	650	6.50
Whippoorwill	" "	" "	Beginning to trail	Vines 4 to 5 ft.—in bloom	Late	675	6.75
Hammond's Extra Early	" "	" "	Beginning to trail	Vines 3 to 5 ft —pods forming	Medium	675	6.75
Wonderful	" "	" "	Erect	Vines 3 to 4 ft.—budded	Late	700	7.00
Mount Olive	" "	" "	Trailing—vines 2 to 3 ft	Vines 5 to 8 ft.—pods formed	Early	725	7.25
New Era	" "	" "	Beginning to trail	Vines 4 to 5 ft.—pods forming	Medium	740	7.40
Early Black	" "	" "	Trailing—vines 1 to 2 ft	Vines 3 to 5 ft.—pods formed	Early	785	7.85
Clay	" "	" "	Trailing—vines 1 to 2 ft	Vines 3 to 5 ft.—budded	Late	850	8.50
Gallavant	" "	" "	Erect	Vines 2½ to 3 ft —budded	Late	910	9.10
Taylor	" "	" "	Beginning to trail	Vines 3 to 5 ft.—pods formed	Early	925	9.25
Small Black	" "	" "	Beginning to trail	Vines 4½ to 5½ ft.—pods forming	Medium	940	9.40
Southdown	" "	" "	Beginning to trail	Vines 3 to 4 ft.—pods forming	Medium	980	9.80
Red Ripper	" "	" "	Erect	Vines 2 to 3 ft.—pods forming	Late	1,000	10.00

It is noticeable that the time the varieties matured had but little influence upon the yield—that is, early, medium and late varieties are found both among the high and low-yielders. The tabulation also shows that nearly all the varieties that began to trail the first fifty days were early. It should be noted, therefore, that where it is desired to plow the crop under the later or more erect varieties should be selected. The erect or slightly trailing varieties are also more desirable for forage when the mowing-machine is used in harvesting. If, however, the crop is pulled, as is the custom among some farmers, who grow cow peas in small quantities, or if the crop is allowed to lie on the ground over winter to be turned under in the spring, a good trailing variety can be recommended. Of the erect varieties, the Red Ripper proved the best—in fact, it out-yielded all others. Among the medium trailers, the Southdown, Small Black and Taylor are all good. The Mt. Olive and Black-Eye were the longest trailers, but gave a comparatively low yield. Figs. 12, 13 and 14 show types of the different varieties.

Soy Beans.—A crop similar to the cow pea, but more difficult to grow. If the soil is a little too moist the seed will rot, even where cow peas would flourish. Further, the plants are not as palatable and the yield is usually somewhat less than cow peas.

Cow Peas and Kaffir Corn.—A valuable crop in favorable seasons. Yields of twelve tons per acre have been secured. Two acres sown in June this year yielded but 7.6 tons.

Cow Peas and Millet.—A good combination of plants as regards composition, the cow peas being rich in protein, while the millet contains a high percentage of carbohydrates. The millet, however, grows faster and matures earlier than the peas, hence the latter are constantly shaded and do not fully develop. The yield, however, was good. One field, top-dressed with nitrate of soda, yielded at the rate of ten tons per acre.

Corn.—This crop occupies an important place in the forage rotation. It is one of the best we have to feed early in the fall. The selection of the variety is very important if the best results are to be secured. The Thoroughbred White Flint continues to be one of the best kinds we can grow for this purpose, owing to its succulent habit and heavy, leafy growth. This year some of our cornfields were almost completely destroyed by blackbirds,

Fig. 15.
"After Taking."

which came in large flocks and pulled the corn as soon as it appeared above ground. Their destruction was made the subject of an experiment.

Experiments in Destroying Blackbirds.

Blackbirds were particularly destructive this year to newly-planted corn. A field of three acres at the College Farm was almost completely destroyed the first week in July. Several poisons were used, including Paris green, corrosive sublimate (mercuric chlorid) and strychnine. The method used consisted in soaking corn for two hours in hot water, the water then being drained off and the poison mixed with the moist corn. It was then spread on the field where the birds worked. Paris green and corrosive sublimate had but little, if any, effect. It was eaten sparingly, although it all disappeared in a few days. The strength of the poison doubtless decreased from exposure. Strychnine, however, proved all that could be desired in their destruction. The plan followed was essentially the same as described above. One-eighth of an ounce was used to a peck of corn. On the evening of July 17th the poisoned corn was distributed in patches over a three-acre field, where the birds were working ravenously, not only in pulling up corn, but in digging up that which had just been planted and not yet sprouted. On the following morning the writer collected sixty-nine blackbirds of the largest kind, found dead or dying on various parts of the field and under trees in the adjoining woods; thirty-nine were collected later, making a total of 108. Doubtless there were a large number in the woods that were not found, and still others that flew farther away before they succumbed. Continued use of the poison destroyed or frightened away the rest and the field was no longer disturbed. Fig. 15 shows the birds lying on the field after taking the poison.

Barley.—The latest forage fed in the fall. It is our practice to seed rye, wheat or crimson clover with the barley about the 1st of August. The barley is cut in October, and the other crop holds over the winter, and is used for early forage in the spring. The plan has proven an excellent one and four acres were treated in this manner this fall.

Soiling Crop Rotations, 1903.

The arrangement of crops shown in Table IV. furnished a continuous supply of forage for the dairy herd from May 1st until October 20th. The wheat on acres 3, 4 and 5, the alfalfa on acre 8, and the crimson clover on acres 13, 14 and 15, were used for green manure. The total yield per acre for all crops in the year's rotation shows a profitable return. Leaving out of consideration the crops that were turned under, and the mixed grasses, which were not in the regular rotation, six acres yielded less than ten tons, eleven acres yielded more than ten tons and less than fifteen, four yielded over fifteen and less than twenty, while one yielded over twenty tons. The average yield per acre for the crops in the regular rotations, not including those turned under, was 12.15 tons.

A comparison of the amount of nutrients obtained per acre from the various combinations of crops, with that contained in clover hay, will serve to give a better idea of their feeding value. For example, on acre 18 (alfalfa) the protein is equivalent to that contained in 6.5 tons of clover hay, or 5.7 tons of wheat bran. On acres 3, 4, 10, 13, 14 and 19, it is equivalent to that in more than three tons of clover hay. In 1, 2, 5, 9, 11, 12, 14 and 15, to more than two tons, and on the remaining eight acres to an average of 1.47 tons. In nearly every case the proportion of carbohydrates is equal to or slightly exceeds the proportion contained in clover hay, thus making the nutrients comparable with this crop. The nutrients contained in three tons of wheat bran and corn meal, respectively, are also added in the table for comparison.

On nine acres, three crops are grown within a year, but with the exception of plots 11 and 12, the yield from only two acres is included, as the third crop was turned under. The actual yield, therefore, was larger than is indicated. On eleven acres, two crops were grown and on the remaining plots only one.

TABLE IV.

Soiling Crops—Number, Kind and Acreage, 1903.

Number of acre.	CROP ROTATION.	Yield per acre.	NUTRIENTS. Protein.	Ether extract.	Fiber and N. free extract.
		tons.	lbs.	lbs.	lbs.
1	Rye	6.70	347.73	80.4	2,441.95
	Cow Peas and Millet	9.05	364.80	154.2	3,162.00
	Total	15.75	712.53	234.6	5,603.95
2	Rye	5.00	259.50	60.00	1,822.35
	Cow Peas and Millet	10.05	417.36	172.19	996.09
	Total	15.05	676.86	232.19	2,818.44
3	* Wheat	......	......	......	......
	Peas and Oats	5.55	588.30	72.15	1,143.30
	White Flint Corn	7.00	231.00	86.80	2,316.30
	Total	12.55	819.30	158.95	3,459.60
4	* Wheat	......	......	......	......
	Peas and Oats	5.55	588.30	72.15	1,143.30
	White Flint Corn	7.00	231.00	86.80	2,316.30
	Total	12.55	819.30	158.95	3,459.60
5	* Wheat	......	......	......	......
	Peas and Oats	5.34	556.04	69.42	1,100.04
	White Flint Corn	7.00	231.00	86.80	2,316.30
	Total	12.34	787.04	156.22	3,416.34
6	Crimson Clover	4.15	255.00	42.50	969.00
	Cow Peas and Kaffir Corn	3.60	97.20	39.60	1,004.40
	Seeded to Alfalfa, August 13th	......	......	......	......
	Total	7.85	352.20	82.10	1,973.40
7	Crimson Clover	4.25	255.00	42.50	969.00
	Cow Peas and Kaffir Corn	4.00	108.00	44.00	1,116.00
	Seeded to Alfalfa, August 13th	......	......	......	......
	Total	8.25	363.00	86.50	2,085.00
8	*Alfalfa	......	......	......	......
	Barnyard Millet	13.60	435.20	240.80	5,807.20
	Reseeded to Alfalfa, August 6th	1.00	83.00	18.00	323.00
	Total	14.60	518.20	258.80	6,130.20
9	Wheat	10.34	597.04	186.12	3,701.72
	Sweet Corn	5.00	177.05	61.00	1,849.00
	Total	15.34	756.09	247.12	5,550.72
10	Wheat	10.34	579.04	186.12	3,701.72
	Cow Peas	6.04	347.90	93.02	1,208.00
	Total	16.38	926.94	279.14	4,909.72
11	Rye	4.24	220.48	50.88	1,543.36
	Vetch and Oats	5.10	339.52	112.54	2,292.28
	Barley	3.40	183.60	40.80	1,074.00
	Total	12.74	743.60	204.22	4,909.64

*Used for green manure.

TABLE IV.—Continued.

Soiling Crops—Number, Kind and Acreage, 1903.

Number of acre.	CROP ROTATION.	Yield per acre.	NUTRIENTS. Protein.	Ether extract.	Fiber and N. free extract.
		tons.	lbs.	lbs.	lbs.
12	Rye	4.24	220.48	50.88	1,543.36
	Vetch and Oats	5.10	339.52	112.54	2,292.28
	Barley	3.40	183.60	40.80	1,074.00
	Total	12.74	743.60	204.22	4,909.64
13	*Crimson Clover	....	....	....	....
	Peas and Oats	7.30	773.80	90.52	2,415.57
	Barley	4.00	216.00	48.00	1,264.00
	Total	11.30	989.80	138.52	3,679.57
14	*Crimson Clover	....	....	....	....
	Peas and Oats	6.30	667.80	81.90	1,297.80
	Barley	3.30	178.20	39.60	1,042.80
	Total	9.60	846.00	121.50	2,340.60
15	*Crimson Clover	....	....	....	....
	Peas and Oats	6.60	699.60	85.80	1,359.60
	Sorghum	2.50	68.00	25.50	587.50
	Total	9.10	767.60	111.30	1,947.10
16	Wheat	6.90	386.40	124.20	2,470.20
	Barnyard Millet	2.75	88.00	49.50	1,174.25
	Total	9.65	474.40	173.70	3,644.45
17	Wheat	5.30	296.80	95.40	1,897.40
	Barnyard Millet	2.00	64.00	36.00	854.00
	Total	7.30	360.80	131.40	2,751.40
18	Alfalfa	21.36	1,775.02	378.07	6,900.42
19	Alfalfa	11.15	925.45	200.70	3,601.45
20–22	Crimson Clover	9.00	540.00	90.00	1,971.00
	Corn	21.73	572.59	193.57	7,983.60
	Total	30.73	1,112.59	283.57	9,954.60
23–24	Mixed Grasses	12.20	1,146.80	292.80	5,124.00
25–35	Mixed Grasses (second crop)	20.08	1,887.52	481.92	8,433.60
	Four tons clover hay contains		1,080	264	5,040
	Three " " " "		810	198	3,780
	Two " " " "		540	132	2,520
	Three tons wheat bran contains		924	246	3,240
	Three tons corn meal "		558	228	4,200

* Used for green manure.

Forage vs. Silage.

For the past seven years the roughage used in the rations for the dairy herd was composed largely of soiling crops from May 1st until November 1st, and of silage for the remaining six months. There is, therefore, an opportunity given to compare the results of the two systems. Table V. shows the average yield of milk and the amount and percentage of butter-fat produced by the herd. Only those animals are included in the record which remained in the herd during the entire year.

TABLE V.

Summary Record of the Dairy Herd, Showing Average Yields of Milk and Fat During the Soiling and Silage Periods.

YEAR.	Number of cows.	SOILING PERIOD. MAY 1st—NOVEMBER 1ST. AVERAGE YIELD PER COW OF—				SILAGE PERIOD. NOVEMBER 1ST—MAY 1ST. AVERAGE YIELD PER COW OF—			
		Milk.	Fat.	Butter.	Fat.	Milk.	Fat.	Butter.	Fat.
		lbs.	lbs.	lbs.	%	lbs.	lbs.	lbs.	%
1897	21	3,414	144.5	168.6	4.23	2,941	123.1	143.6	4.18
1898	20	3,174	140.7	164.2	4.43	2,970	132.0	154.0	4.44
1899	12	3,889	164.3	191.7	4.23	3,078	137.8	160.8	4.48
1900	27	3,390	153.4	179.0	4.53	2,975	137.2	160.1	4.61
1901	26	3,250	137.1	160.0	4.22	3,287	144.2	168.2	4.39
1902	30	3,624	153.8	179.4	4.24	3,046	127.7	149.0	4.19
1903	26	3,076	133.7	156.0	4.35	2,871	124.9	145.7	4.35
Average	....	3,402	146.8	171.3	4.31	3,024	132.4	154.5	4.38

The tabulation shows the average yield of milk per cow during the soiling and silage periods to be 3,402 and 3,024 pounds, respectively, a difference of 378 pounds in favor of soiling. The average yield of butter was 171.3 pounds for the soiling period and 154.5 for the silage period, a difference of 16.8 pounds, also in favor of soiling. The average percentage of fat for the two periods

was practically the same, namely, 4.31 and 4.38. The number of fresh cows each month during the year was quite uniform, hence the comparison of yields from the two systems is a fair one and shows that both systems are practicable in respect to the quantity, as well as the quality, of the product produced. On small farms, where it is desired to keep the largest herd possible, it is necessary that every acre be made to produce to its highest capacity. The above systems of summer and winter feeding doubtless come the nearest to accomplishing this.

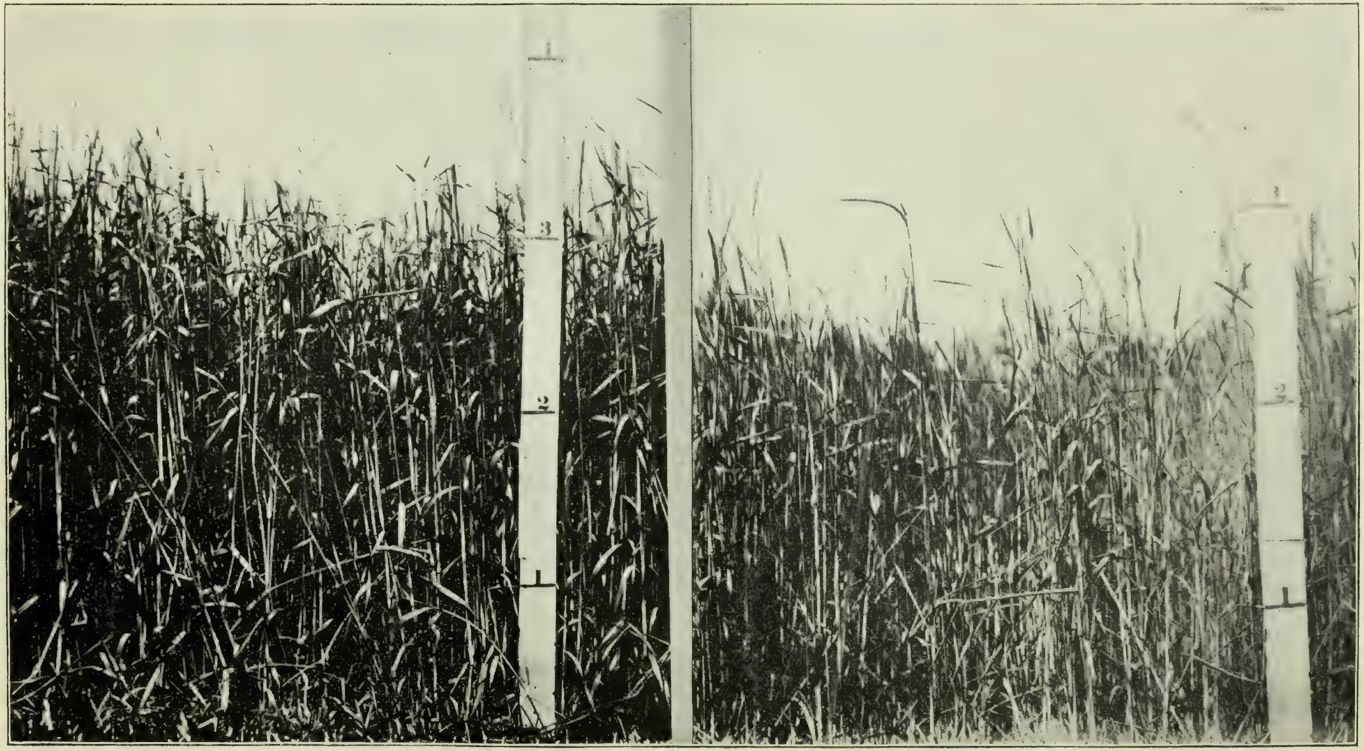
Experiments with Nitrate of Soda on Mixed Grasses, Rye, Wheat, Barley, Cow Peas and Millet.

This work is similar to that described in the report of this Station for 1902. Two acres were included in the experiment with each crop, except in the case of mixed grasses, where only one acre was used. One acre was treated with nitrate of soda as a top-dressing, while the other, untreated, served in making the comparison. The objects of the experiments were (1) to study the effect of nitrate of soda upon the yield of the crop, and (2) to determine whether its use on forage crops was practicable from a financial standpoint. The following table shows the date and the amount of the application on the different crops and the yield from the treated and untreated plots:

TABLE VI.

KIND.	Date of application.	Amount of nitrate applied.	Date of cutting.	YIELD. Untreated acre.	YIELD. Treated acre.	GAIN. Tons.	GAIN. Per cent.	GAIN. Value at $3.50 per ton.	Cost of nitrate per acre.	Net gain over cost.
		lbs.		tons.	tons.					
Mixed Grasses	April 21.	*200	July 7- 9.	4.00	5.42	1.42	35.5	$4 99	$4 00	$0 99
Rye	April 1.	200	May 4-10.	5.00	6.70	1.70	34.0	5 95	4 50	1 45
Wheat	April 1.	150	May 22-31.	5.30	6.90	1.60	31.3	5 60	3 37	2 23
Barley	Aug. 20.	*200	Oct. 6-16.	3.30	4.00	.70	21.0	2 45	4 00	−1 55
Cow Peas and Millet	July 16.	*200	Aug. 9-17.	9.05	10.05	1.00	10.9	3 50	4 00	− 50

* Nitre—Lime complete.



Treated plot.

Fig. 17.

Untreated plot.

Experiment with Nitrate of Soda on Rye.

Height, 2½ feet. Height, 3½ feet.

Fig. 18.

Experiment with Nitrate of Soda on Wheat.

Untreated plot. Treated plot.

Treated plot. Untreated plot.

Fig. 19.

Experiment with Nitrate of Soda on Cow Peas and Millet.

The amount of nitrate applied on the different plots ranged from 150 to 200 pounds per acre. The gain in yield ranged from .7 tons in case of the barley to 1.7 tons for the rye. The percentage of gain ranged from 10.9 on the cow peas and millet to 35.5 on the mixed grasses. The net financial gain, which is the most important consideration, ranged from $1.55 on barley to $2.23 on wheat. It is noticeable that the nitrate was most effective when applied early in the season on early crops—that is, the applications made in April on mixed grasses, rye and wheat were all profitable, while applications on crops in July and August were made at a loss. The results, therefore, indicate that top-dressing with nitrate is a desirable practice with such crops as rye, wheat and grasses, not only on account of the increase in yield, but because the gain is made at a time when forage is least abundant.

Seeding Grass on Sod Without Grain.

For several years it has been our practice to seed grass and clover during the month of August without grain. The plan has proved an excellent one, and we have never failed to secure a good stand. In August, 1902, a field that had been in grass two years was plowed, prepared in the usual way, and seeded with a mixture containing the following amounts of seed per acre: Eight pounds of timothy, two of red top, two of alsike clover and seven of red clover. The seed came up well and made considerable growth through the fall. The grasses showed an excellent stand in the spring, and there was also a good percentage of clover. Cutting began July 6th, and although the season was very unfavorable the average yield of cured hay for the first cutting on the ten acres was two tons. The best plots yielded 2.5 tons. Fig. 4 shows the field during harvest. A second crop was also secured in September, which was fed green to the dairy herd. This practice is not a common one among farmers, particularly reseeding on sod. It has some advantages, however, the more important one being that no time is lost in the use of the land—that is, a crop of hay may be taken off in the summer at the usual time, the ground reseeded again to grass, and a good crop secured the following summer. This practice is recommended particularly where it is desired to keep land in grass for a number of years. Whenever the field becomes weedy the sod is simply turned over in the fall and reseeded.

Inoculation Experiments with Alfalfa.

Alfalfa is becoming an important crop in New Jersey. The area devoted to this plant is increasing year by year in the northern part of the State, as well as in the central and southern portions. The difficulty which some farmers experience in growing this crop was believed to be due, in part, at least, to the lack of certain bacteria in the soil which enable the plant to secure its supply of nitrogen from the air. The question appeared to be of sufficient importance to justify an experiment. Soils were, therefore, secured from various parts of the State, each soil representing a considerable area. The objects of the experiment were three-fold—(1) to study the soils representing large areas in the State in respect to their natural adaptability for growing alfalfa; (2) to study the effect of inoculating these soils with alfalfa bacteria; (3) to study the effect of nitrogen in the form of nitrate of soda upon the growth of alfalfa in comparison with bacteria.

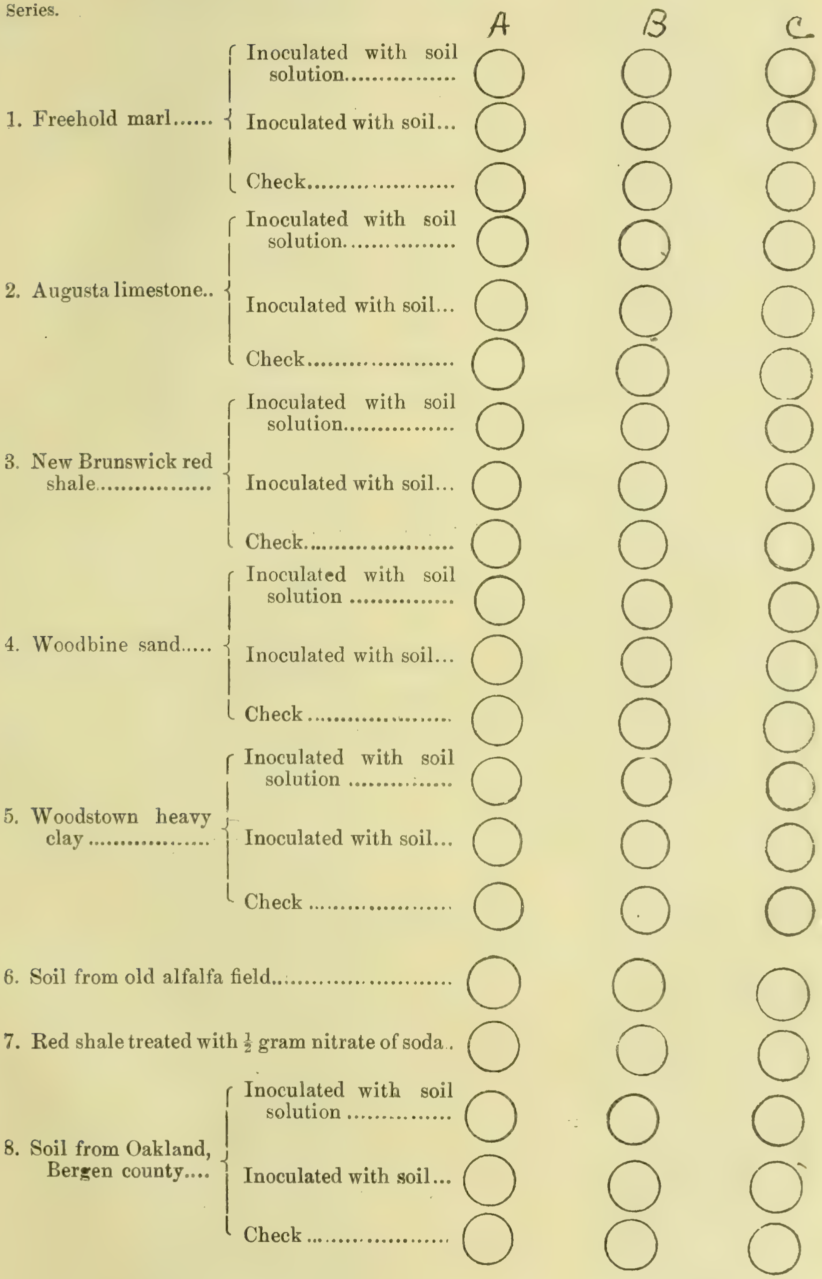
Description of the Experimental Plot.

In order that the conditions of the experiment might conform as nearly as possible to those in actual practice, what is known as the "cylinder method" was adopted.

The cylinders were made of galvanized iron, eight inches in diameter and one foot long, with a bottom supplied with an opening for drainage, and were painted inside and out for preservation. The area of the soil surface thus exposed was, therefore, fifty and one-fourth square inches. The depth was such that the roots would be free to grow for at least two years, or until records could be secured of the effect of inoculation. Forty-five cylinders were used, divided into five groups of nine each. Thus in each group there were three series of three each, A, B and C, enabling a comparison of three crops in each case. In addition to these, nine others were addd for special tests.

Fig. 4.
A Hay crop on Sod Reseeded, 1903.

Diagram of Experiment.



The Soils Used.

The kind of soil for each series and the place where it was obtained are given in the following:

Series.	Kind of Soil.	Name of Contributor.	Town.	County.
1	Heavy loam in marl area	John Henry Denise	Freehold	Monmouth.
2	Limestone	H. D. Roe	Augusta	Sussex.
3	Red shale	N. J. Ag'l College Farm	New Brunswick	Middlesex.
4	Sandy	J. W. Pincus	Woodbine	Cape May.
5	Heavy clay	M. D. Dickinson	Woodstown	Salem.
6	Soil from old alfalfa field	N. J. Ag'l College Farm	New Brunswick	Middlesex.
7	Red shale	N. J. Ag'l College Farm	New Brunswick	Middlesex.
8	Glacial drift	Edward D. Page	Oakland	Bergen.

About 300 pounds of soil was sent to the Station by each of the above parties. It was taken from the field to a depth of one foot, the surface and subsoil being kept separate, and on reaching the Station twenty-five pounds were placed in each cylinder as nearly as possible in the same position as it was found in the original field. Broken tile was placed in the bottom of each cylinder to aid drainage. All the soils were treated with litmus paper to determine their acidity. The soils from Freehold, Augusta, Woodstown, Oakland and the red shale soil of the College Farm gave an acid reaction, showing the need of lime. The soil from the old alfalfa field at the College Farm and the soil received from Woodbine were neutral.

Fertilization.

All the cylinders received a uniform application of fertilizers as follows:

	Amount per cylinder. gms.	Rate per acre. lbs.
Dried blood	$\frac{1}{3}$	98
Muriate of potash	$\frac{2}{3}$	196
Acid phosphate	1	295
Prepared lime	4	1,180

Limestone Soil from farm of Frank Roe, Augusta, Sussex Co., N. J.

Marl Soil from farm of John Henry Denise, Freehold, Monmouth Co., N. J.

Heavy Clay Soil from farm of M. D. Dickinson, Woodstown, Salem Co., N. J.

Sandy Soil from farm of Baron De Hirsh Agricultural School, Woodbine, Cape May Co., N. J.

Inoculation.

Two methods of inoculation were used. Method 1 consisted in taking soil from a field where alfalfa had been grown for five years and applying it to the cylinders to be inoculated at the rate of two grams to each plot, or 590 pounds per acre. The inoculating soil was thoroughly mixed with the surface soil in the cylinder at the time of seeding.

Method 2 consisted in taking soil from the same source as above and making a solution by mixing one pound of soil (453.6 grams) with 1,000 cc. (about 1 qt.) of water, and allowing the contents to settle. One cc. of the liquid was applied to each of the cylinders to be inoculated for every alfalfa seed planted.

The inoculated cylinders in each series are indicated in the above tabulation. The cylinders in the photographs marked Bac. A indicate that they were inoculated by method 1, and those marked Bac. B, by method 2.

Seeding.

All the cylinders were planted May 28th, fifty seeds being placed in each cylinder. The seed started immediately and a uniform stand was secured. The crop was carefully watched, and as no water, or at least a very small amount, could enter the cylinders from below they frequently became dry. During the growth of the first crop they were watered six times, while the second crop required no moisture except the natural precipitation. Very marked differences were noted in the growth of the crops. The alfalfa in series 6 (soil from old alfalfa field) attained the largest growth and showed the richest color from the start. Series 2 (Augusta, limestone) and 5 (Woodstown, clay) also made a vigorous growth, showing that these soils were naturally adapted to the growth of alfalfa. The inoculated cylinders in most of the series, particularly those treated with the soil solution, showed a marked gain over the uninoculated cylinders. As might be expected in the first year of experimentation, variations in the different plots of the series were found to be large, not only in the check cylinders, but in all. This was undoubtedly largely due to the fact that the soil had been recently prepared. The results, however, from groups of three were sufficiently uniform to admit of comparison. It was not expected that the results would be very

marked the first season; two cuttings were harvested, however, one August 14th and the other October 6th, careful records being kept of the yields in all the cylinders.

The Results of the First Year's Experiment.

The following table shows the actual yields from the different series of cylinders from both the first and second cuttings and the gain from inoculation:

TABLE VII.

Results of Experiment.

Groups.	SERIES.	Aug. 14. Total three cylinders.	Gain over check cylinders.		Oct. 6. Total, three cylinders.	Gain over check cylinders.		Total gain over check cylinders—two cuttings.	Per cent. gain—two cuttings.
		gms.	gms.	%	gms.	gms.	%		
1	A	51	4		44	—4			
	B	52	5		43½	—4½		½	.5
	C	47			48				
2	A	102½	31		101	43		74	57.1
	B	97½	26		83½	24½		50½	39
	C	71½			58				
3	A	73½	30½		91½	44½		75	83.3
	B	36½	—6½		71½	24½		18	20
	C	43			47				
4	A	89	52		68			52	52
	B	75	38		52	—16		22	22
	C	37			68				
5	A	86½	8		84	22		30	21.3
	B	69½	—9		62			—9	—6.4
	C	78½			62				
6		142			156				
7		56½			92				
8	*A	58½	22½		45	3		25½	32.7
	*B	†24	—12		30	—12		—24	—30.7
	*C	36			42				
Total	A	461	148	47.3	433½	108½	33.5	256½	40.2
	B	354½	41½	13.3	342½	16½	5.1	58	9.1
	C	313			325				

* Results multiplied by three for comparison with other series.
† Poor stand of alfalfa.

Red Shale Soil Inoculated with soil from old Alfalfa field.

Red Shale Soil Not Inoculated but Treated with Nitrate of Soda at the rate of 147 pounds per acre.

Soil from old Alfalfa field on the New Jersey Agricultural College Farm.

Red Shale Soil from the New Jersey Agricultural College Farm, New Brunswick, Middlesex Co.

In the first place, it will be noted that the cylinders in group 6, which contained the soil from the old alfalfa field, showed the highest yield of any at the time of first cutting, viz.: 142 grams. This would naturally be expected, as the soil was thoroughly inoculated (alfalfa having been grown upon it for five years). It was the same field from which the soil was taken to inoculate the other cylinders.

The yields in series A (inoculated with soil solution), in each group, are shown to be the highest, with the exception of group 1, than B (inoculated with soil) or C (check). The total yield from the cylinders in series A is shown to be 461 grams. There was, therefore, a gain over the check cylinder of 148 grams, or 47.3 per cent. Again, the total of the B series (inoculated with soil) in all the groups is shown to be 354½ grams. Subtracting from this the total of the check cylinders, 313 grams, we have a balance of 41½ grams, or 13.3 per cent., which represents the gain from the inoculation with soil.

A further study of the table shows that there was a gain on all the cylinders inoculated with the soil solution. Series 1, containing the marl from Freehold, showed the lowest gain—four grams—and series 4, containing the sandy soil from Woodbine, the highest—fifty-two grams. The total yield from the cylinders inoculated with the soil solution was 461 grams, which was a gain over the check or non-inoculated cylinders of 148 grams, or 47.3 per cent. Again, the cylinders inoculated with soil showed a total gain on all series of 13.3 per cent.

Looking at the yields from the second cutting, made October 6th, it will be noticed again that with the exception of groups 1 and 4, the yields from series A considerably exceeds series B, and particularly series C, or the check series. The total of the A series for this cutting was 433½ grams. Subtracting the total from the check series, 325 grams, we have a balance of 108½ grams, or 335 in favor of inoculation with soil solution. The total for the B series was 342½ grams. Subtracting again the total from the check series, there remains a balance of 16½ grams, or 5.1 per cent., due to inoculation with soil. The gain from both methods of inoculation was considerably less from the second cutting than from the first. This may have been due to the slower action of the

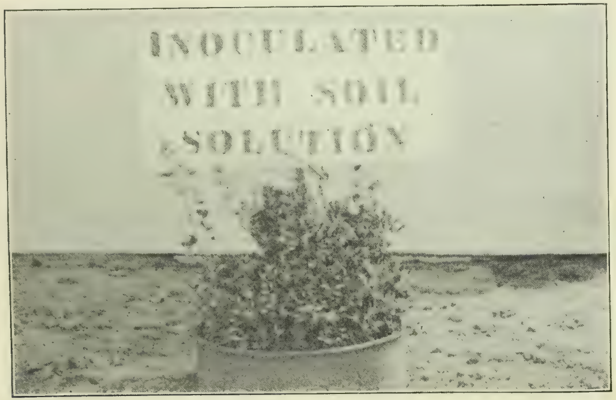
bacteria during the latter part of the season, which was much cooler. A summary of the yields from the two cuttings is interesting and indicates the gain that might be expected the first season. The gain from inoculation with soil solution amounted to 256½ grams, or 40.2 per cent., and with soil, 58 grams, or 9.1 per cent.

The Natural Adaptability of the Soils for Growing Alfalfa.

As already stated, the soils in groups 1, 2, 3, 4, 5 and 8 were secured from different parts of the State and represented large areas. The natural adaptability of the soils may perhaps be best determined by the yields from all the cylinders in each group, as the different groups received the same treatment. The yields were as follows:

		Group 5. Woodstown heavy clay. gms.	Group 8. Oakland glacial drift. gms.	Group 1. Freehold marl. gms.	Group 2. Augusta lime-stone. gms.	Group 3. New Brunswick red shale. gms.	Group 4. Woodbine sand. gms.
First cutting, Aug. 14...	A	86½	58½	51	101½	73½	89
	B	69½	24	52	97½	36½	75
	C	78½	36	47	71½	43	37
Second cutting, Oct. 6..	A	84	45	44	101	91½	68
	B	62	30	43½	83½	71½	52
	C	62	42	48	58	47	68
		442½	235½	285½	514	363	389

The limestone soil secured from Augusta, Sussex county, and which represents a considerable section in the northwestern part of the State, gave the highest yield, 514 grams. The heavy clay soil from Woodstown, representing a very fertile section in the southwestern part of the State, yielded the next highest, 442½ grams. The red shale soil, which represents a large area extending north and east from the centre of the State, and the sandy soil which covers all of the southern portion, yielded 363 and 389 grams, respectively. The soil from Freehold, Monmouth county, and Oakland, Bergen county, gave the lowest yields, namely, 285½ and 235½ grams, respectively. These two soils not only yielded the lowest naturally, but also responded the least to inoculation.



The above figures show some of the cylinders which demonstrate in a marked degree the effect of inoculation.

Nitrate of Soda vs. Bacteria.

An interesting part of the experiment was a comparison of yields between cylinders inoculated with alfalfa bacteria and cylinders filled with the same soil treated with nitrate of soda, the object being to note whether the bacteria could take the place of nitrate of soda in supplying nitrogen to the crop and *vice versa*. Group 3, series A, and group 7, both of which contained red shale soil, admitted of this comparison, series A, in group 3, being inoculated with soil solution, which cost practically nothing, while group 7 was treated with nitrate of soda at the rate of 147 pounds per acre, costing $3.31. The yield from the inoculated and nitrated cylinders August 14th was 73½ and 56½ grams, respectively. There was, therefore, a balance of 17 grams, or 30 per cent. in favor of inoculation. Again, it will be noted that at the time of the second cutting, October 6th, the yields were 91½ and 92 grams on the inoculated and nitrated, respectively, or practically the same. Here, also, it is evident that the bacteria were less active during the latter part of the season, which was cooler. These results are at least suggestive. The experiments will be continued, and no doubt another year's records will throw more light on the subject and possibly substantiate the results already secured.

Conclusions from First Year's Experiment.

1. Inoculation with alfalfa bacteria in "soil solution" and in "soil" produced an average gain of 40.2 and 9.1 per cent., respectively, in two crops of alfalfa, over cylinders not inoculated.

2. All soils did not respond alike to inoculation. A variation of 0 to 83 per cent. was noted in case of inoculation with "soil solution," and 30.7 to 43.9 per cent. where the inoculation was made with "soil." It should be noted, however, that in the latter instance the loss of 30.7 per cent. was due, in part, at least, to a poor stand of alfalfa.

3. A wide variation was found in the natural adaptability of soils in different parts of New Jersey for growing alfalfa. A difference of 118 per cent. was noted in groups of cylinders containing the different kinds of soil.

4. Cylinders inoculated with "soil solution" produced 11.1 per cent. more alfalfa the first season than those treated with nitrate of soda at the rate of 147 pounds per acre, costing $3.31.

Cost of Producing Milk.

Beginning April 1st, 1896, records have been kept of the cost of labor, the kind, amount and cost of foods eaten by the dairy herd and the amount of milk produced by each cow. The cost of producing milk in previous years has been published in the annual reports. The cost for the year ending April 1st, 1903, is here reported. The herd averaged thirty-four cows.

TABLE VIII.

The Kind, Amount and Cost of Foods for Thirty-four Cows for One Year, April 1st, 1902, to April 1st, 1903.

	Amount fed. lbs.	Cost per ton.	Total.	
Wheat bran	26,000	$20 40	$265 20	
Dried grains	35,500	18 90	335 48	
Buckwheat middlings	1,500	14 00	10 50	
Wheat middlings	3,000	20 00	30 00	
Rice meal	4,500	20 00	45 00	
Gluten meal	3,000	24 25	36 37	
Cottonseed meal	5,400	29 00	78 30	
Hominy meal	3,000	24 00	36 00	
Cost of feeds				$836 85
Soiling crops	360,000	1 60	288 00	
Silage	234,000	2 40	280 80	
Dried cornstalks	20,000	4 00	40 00	
Mixed hay	16,000	5 00	40 00	
Roughage				648 80
Total cost of food				$1,485 65

Total cost of food	$1,485 65	
Cost per cow per day		11.97 cents.
Cost of feeds	836 85	
Cost per cow per day		6.74 cents.
Cost of roughage	648 80	
Cost per cow per day		5.23 cents.
Total yield of milk	98,574	quarts.
Average per cow per day	7.94	"
Cost of food per quart		1.51 cents.
Cost of feed per quart		.85 "
Cost of roughage per quart		.66 "

The cost of feeds represents what was actually paid. The cost of hay, cornstalks and soiling crops represents the actual cost of labor, seed, manures and fertilizers, the farm manures being charged at the rate of $1.50 per ton. Fifteen of the nineteen forage acres received manure at the rate of eight tons per acre.

The average cost of the daily ration was 11.97 cents, of which 6.74 cents, or 56.3 per cent., is represented by purchased feeds and 5.23 or 43.7 per cent. by the cost of farm crops. The total cost of producing milk, including the cost of labor and the interest on and decrease in, the value of the herd are given, the latter item being estimated.

Foods, as per statement		$1,485 65
Labor	$600 00	
Interest on value herd at 5 per cent	68 00	
Decrease on value herd at 5 per cent	68 00	
		736 00
Total		$2,221 65
Cost of food per quart of milk		1.51 cts.
Cost of labor and interest per quart of milk		.75 cts.
Total cost per quart		2.26 cts.

The average weight per quart of milk as put up in bottles for delivery was 2.18 pounds, hence the total weight of milk, 214,891 pounds, was equivalent to 98,574 quarts. The cost per hundred was, therefore, $1.03. At $1 per hundred, the price received in many rural districts, the profits from the business, if any, must be found in the manure. In the calculation of the cost of farm foods the manure was charged at the rate of $1.50 per ton. The amount produced by the herd during the year was 370 tons. In selling milk for $1 per hundred, the receipts are $72.74 less than the expense. Deducting this amount from the actual charges made for manure, in the growing of the crops—$1.50 per ton—there remains $482.26, which represents the profits from thirty-four cows, an amount too small to make the business pay. In rural districts, however, where pasture is abundant, the cost of food would not be as great as where soiling crops supply the entire ration, with the exception of concentrates.

At 3½ cents per quart, the price that could have been received at wholesale, the receipts would have amounted to $3,450.09. Deducting the cost of purchased feeds, labor and interest and decrease in the value of the herd, amounting to $1,572.85, we have a balance of $1,877.24, which represents the value of the

home-grown crops; or, in other words, at 3½ cents per quart for milk, the farm would sell its produce to the dairy at profitable prices, namely, $4.62 per ton for soiling crops, $6.94 for silage, $14.45 for hay and $11.56 for dried corn stover, a gain over cost of production of $3.02 per ton for soiling crops, $4.54 for silage, $9.45 for hay and $7.56 for dried corn stover, besides an additional gain represented by 370 tons of manure.

Looking at the question of profit from another standpoint, we will assume that the dairyman performs the work himself. Deducting, therefore, the item of labor, which amounted to $600, from the total cost of production ($2,221.65), we have a balance of $1,621.65. Dividing this amount by the total pounds of milk produced (214,891), we find the cost per hundred to be 75½ cents. The difference, therefore, between the cost and selling price of th milk represents the dairyman's profits when he performs the work himself.

Assuming that the milk produced by the above thirty-four cows had been sold for $1 per hundred, a profit of 24½ cents would have been realized from every hundred pounds, or a total of $526.48 for the year's production, besides the additional gain represented by the 370 tons of manure. At 3½ cents per quart, the profits would have amounted to $1,818.44, besides the additional gain from the manure—a good salary for a dairyman.

TABLE IX.

Average Cost of Producing Milk for Seven Years.

YEAR.	Number of cows.	MILK PRODUCED.		Average yield per cow.	COST PER COW PER DAY.			COST PER QUART OF MILK OF—			
		Pounds.	Quarts.		Feeds.	Roughage.	Total.	Feeds.	Roughage.	Labor and interest.	Total.
				lbs.	cts.	cts.	cts.	cts.	cts.	cts	cts.
1896	23	141,517	64,916	6,153	4.99	6.61	11.60	.646	.855	.99	2.49
1897	25	154,758	70,990	6,791	5.06	6.38	11.41	.650	.820	.92	2.39
1898	25	172,726	79,232	6,911	6.53	6.16	12.69	.750	.710	.82	2.28
1899	30	198,345	90,934	6,612	6.65	6.58	13.23	.800	.790	.79	2.38
1900	30	195,875	89,851	6,529	7.30	5.35	12.65	.890	.650	.80	2.34
1901	30	191,304	87,754	6,377	7.62	5.26	12.88	.950	.660	.82	2.43
1902	34	214,891	98,574	6,320	6.74	5.23	11.97	.850	.660	.75	2.26
Average	......	181,315	83,186	6,528	6.41	5.94	12.35	.791	.735	.84	2.37

The average production per year for the seven years is shown to be 181,345 pounds, equivalent to 83,186 quarts. The average yield per cow was 6,528 pounds. The average cost of food per cow per day was 12.35 cents, of which 6.41 cents, or 51.9 per cent., represents purchased feeds and 5.94 cents, or 48.1 per cent., farm crops. The average cost per quart of milk for the seven years, including food, labor and interest and decrease in the value of the herd is shown to be 2.37 cents.

The Dairy Business in Relation to Soil Exhaustion.

The following tabulation shows the amount of fertilizing elements contained in the feeds purchased and in the milk produced by the herd for seven years. There is a decided gain to the farm in all the elements of fertility each year. The total gain is equivalent in nitrogen and phosphoric acid to that contained respectively in 27.6 tons of nitrate of soda, 29.6 tons of acid phosphate and in potash to that contained in 2.47 tons high-grade muriate of potash. It is not affirmed that the constituents contained in the manure are equal in agricultural value to those contained in the fertilizers mentioned, or that even under the best conditions of care and application, they could all be used by the plants, but, because the manure contains all the constituents and is well adapted for most crops, the general farmer is, as a rule, able to get as good returns from it in proportion to constituents contained as from products containing the same constituents in more available forms.

The tabulation shows, further, that if all the milk sold from the farm was obtained from foods grown on the farm, the exhaustion of nitrogen would be in greater proportion than the mineral elements, and that when this is the practice it is necessary to apply nitrogenous fertilizers in order to maintain the fertility. If manure is well cared for and used properly, it is more economical to purchase the nitrogen in the form of feeding stuffs, whose whole cost is returned in the increased product resulting from the use of well-balanced rations.

TABLE X.

KINDS.	AMOUNT.							NITROGEN.						
	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1896.	1897.	1898.	1899.	1900.	1901.	1902.
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Wheat Bran	9.40	12.50	14.50	15.85	17.00	12.00	14.50	460	612	710	777	833	588	710
Dried Brewers' Grain	9.20	8.15	10.25	13.75	13.05	12.00	17.75	662	587	838	990	940	864	1,278
Corn Meal	6.10	3.30	5.00	7.05	7.50	6.00	1.50	201	109	165	233	248	198	50
Linseed Meal	3.55	4.45	3.50	1.05	.90	1.00		377	478	372	111	95	107	
Malt Sprouts						1.50							124	
Cottonseed Meal				1.75	4.50	3.00	2.70				238	612	406	365
Gluten Meal							1.50							158
Rice Meal			1.75	2.70		2.40	2.25			69	105		94	110
Pea Meal					1.00							32		
Buckwheat Feed			.50	1.60		2.00	.75			36	29		179	68
Total or Gain in Feeds								1,700	1,781	2,190	2,483	2,760	2,560	2,739
Sold in Milk	70.86	77.38	86.36	99.17	97.94	95.65	107.44	849	927	1,036	1,190	1,173	1,146	1,289
Gain to Farm								851	854	1,154	1,293	1,587	1,414	1,450
Total gain in seven years								8,603						

Fig. 7.
A crop of Vetch and Oats.

Fig. 16.
A field of Barley.

TABLE X.—Continued.

KINDS.	PHOSPHORIC ACID.							POTASH.						
	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1896.	1897.	1898.	1899.	1900.	1901.	1902.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Wheat Bran	545	725	841	919	986	691	835	301	402	464	507	544	391	473
Dried Brewers' Grain	202	179	226	303	287	264	891	15	13	17	22	21	19	28
Corn Meal	85	46	70	99	105	84	21	49	26	40	56	60	48	12
Linseed Meal	126	158	124	38	32	38	....	97	121	96	29	24	28	....
Malt Sprouts	....	....	....	....	....	49	....	....	....	....	....	....	56	....
Cottonseed Meal	....	....	....	106	275	185	167	....	....	....	66	171	114	103
Gluten Meal	....	....	....	....	....	....	17	....	....	....	....	....	....	2
Rice Meal	....	....	94	145	....	129	122	....	....	25	39	....	35	32
Pea Meal	....	....	....	....	16	....	....	....	....	....	....	20	....	....
Buckwheat Feed	....	....	18	58	....	88	33	....	....	13	42	....	46	18
Total or Gain in Feeds	958	1,108	1,373	1,668	1,701	1,528	1,586	462	562	655	761	840	737	668
Sold in Milk	318	347	389	446	440	429	483	248	271	302	347	343	335	376
Gain in Farm	640	761	984	1,222	1,261	1,099	1,103	214	291	353	424	497	402	792
Total gain in seven years				7,070							2,473			

Further Experiments with Parturient Paresis (Milk Fever).

The Schmidt treatment as a cure for milk fever was described in full in the report of this Station for 1902, page 318. It is not necessary, therefore, to give it here. Of the four cows treated last year, two of which were very severe, three recovered. Only one case occurred this year, a description of which is given herewith.

Description of Milk Fever Case.

Genesta, a cow seven years old, calved on the morning of June 2d. She was given a drench immediately for costiveness, after which she appeared to be all right. On the following morning milk fever developed and by 10 o'clock the animal was down and unable to move. The Schmidt treatment was given, and in an hour the cow began to improve, and after two hours she was able to get up. No bad results followed the treatment.

Records of the Dairy Herd, April 1st, 1902, to April 1st, 1903.

Beginning April 1st, 1896, complete records have been kept of the dairy herd, including the yield and composition of the milk of individual animals. These records have been published annually in the Station reports.

The herd consists largely of grade animals. One Guernsey, three Holsteins and three Ayrshires are pure-bred. Twenty-six animals remained in the herd throughout the entire year, and their records are given in the tabulation. A number of the animals giving the lower records this year were heifers. The average, however, for the herd was 5,952.6 pounds.

As already shown under "Cost of Producing Milk," the foods consumed were only such as to provide a sufficient and well-balanced ration. Soiling crops were fed for practically six months and silage for the remainder of the year. In connection with the weight of the milk, which was taken daily, the product from each cow was sampled and analyzed once in two weeks. The accompanying table shows the monthly yield of milk and its composition, as well as the total yield per cow of milk, of fat and of butter. The butter equivalent is derived from the fat by adding one-sixth.

TABLE XI.

Record of the Dairy Herd.

Name of cow.		April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Total yield.	Average per cent. fat.	Total fat.	Equivalent to butter.
Viola	Pounds of Milk	739.2	815.8	804.1	679.0	623.8	572.3	337.4	23.6	266.7	764.5	650.0	706.3	6,982.7	3.9	274.68	320.46
	Per cent. of Fat	3.9	3.7	3.6	4.0	4.1	4.2	5.2	5.8	4.4	3.9	3.9	3.7	......	......	......	......
Hilda	Pounds of Milk	415.3	68.7	......	179.3	1,285.8	1,269.7	1,070.9	925.5	895.3	839.3	792.8	768.7	8,511.3	3.5	298.81	348.61
	Per cent. of Fat	5.0	4.6	......	3.5	3.2	3.2	3.7	3.8	3.9	3.5	3.6	3.8	......	......	......	......
Model	Pounds of Milk	34.3	741.6	845.3	740.3	655.1	696.4	648.3	657.6	530.2	337.0	393.7	405.3	6,685.1	4.1	275.66	321.60
	Per cent. of Fat	4.5	4.4	4.2	3.8	3.7	3.8	4.2	4.3	4.5	4.1	4.2	4.3	......	......	......	......
Lilith	Pounds of Milk	365.3	397.4	327.1	165.4	569.4	514.1	489.5	433.4	417.1	452.6	438.3	438.1	5,007.7	5.8	291.82	340.47
	Per cent. of Fat	6.0	5.9	6.3	6.0	5.5	5.8	5.7	6.2	6.8	5.2	5.9	5.6	......	......	......	......
Select	Pounds of Milk	48.5	......	870.3	864.7	899.8	844.0	727.4	612.3	595.5	599.8	617.8	530.1	7,209.2	4.1	295.56	344.82
	Per cent. of Fat	6.4	......	3.6	3.7	3.6	3.7	4.5	4.6	4.5	4.3	4.3	4.9	......	......	......	......
Gipsey	Pounds of Milk	931.4	1,024.7	948.0	809.4	730.5	758.1	561.0	103.6	......	......	......	862.3	6,729.0	4.0	292.20	314.07
	Per cent. of Fat	3.9	4.5	3.8	3.6	3.9	4.1	4.5	4.7	......	......	......	3.7	......	......	......	......
Diana	Pounds of Milk	686.4	728.5	671.0	513.5	210.3	......	503.4	866.1	750.9	695.0	617.6	816.3	7,059.0	4.7	334.32	390.04
	Per cent. of Fat	4.9	4.6	4.6	5.7	5.6	......	4.5	4.5	5.2	4.5	4.7	4.2	......	......	......	......
Pearl	Pounds of Milk	608.8	651.6	560.9	341.1	86.2	......	750.5	1,006.7	949.8	916.7	714.0	695.8	7,282.1	4.2	303.32	353.77
	Per cent. of Fat	4.6	4.4	4.0	5.1	4.2	......	4.5	3.7	5.2	3.9	3.9	4.0	......	......	......	......
Victoria	Pounds of Milk	561.8	653.0	662.2	556.7	389.7	88.4	......	......	594.6	1,157.3	863.7	921.6	6,449.0	3.5	224.36	261.75
	Per cent. of Fat	3.5	3.2	3.5	3.7	4.2	4.2	......	......	4.2	3.2	3.4	3.1	......	......	......	......

TABLE XI.—Continued.

Record of the Dairy Herd.

Name of cow.		April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Total yield.	Average per cent fat.	Total fat.	Equivalent to butter.
Beula	Pounds of Milk	571.2	598.0	564.1	376.0	73.8	....	....	325.9	571.7	513.5	402.7	416.1	4,413.0	4.6	201.55	235.14
	Per cent. of Fat	4.7	4.4	4.6	5.4	6.3	....	....	4.3	4.3	4.3	4.7	4.3	....	.....	....	....
Zola	Pounds of Milk	697.7	767.3	588.9	288.6	106.6	114.6	941.6	753.5	677.1	718.9	642.2	679.8	6,976.8	4.1	279.44	326.01
	Per cent. of Fat	4.4	4.1	4.2	4.9	4.5	4.2	3.7	3.9	3.9	3.7	3.9	3.9	....	.....	....	....
Blue	Pounds of Milk	720.4	822.3	802.4	707.4	625.9	661.2	619.4	533.7	554.8	607.0	593.4	592.2	7,840.1	4.5	355.68	414.96
	Per cent. of Fat	5.0	4.6	4.1	4.5	4.4	4.3	4.9	5.0	5.0	4.6	4.5	4.6	....	.....	....	....
Raritan	Pounds of Milk	907.8	885.2	772.4	667.6	553.4	577.7	502.5	409.3	407.1	247.8	....	....	5,930.8	4.3	249.36	290.92
	Per cent. of Fat	4.4	4.1	4.5	4.5	3.9	4.0	3.9	4.0	4.3	4.1	....	....	....	.....	....	....
Rose	Pounds of Milk	....	731.3	685.0	707.3	503.5	525.8	502.2	459.8	462.8	438.1	388.2	410.8	5,814.8	4.5	268.62	313.39
	Per cent. of Fat	....	4.3	4.7	4.2	4.6	4.3	4.9	4.8	4.9	4.7	5.0	4.9	....	.....	....	....
Genesta	Pounds of Milk	230.1	1,100.1	941.9	793.7	662.8	645.6	558.0	481.4	437.2	192.0	....	....	6,042.8	4.0	262.24	305.95
	Per cent. of Fat	3.8	4.1	3.7	4.0	4.4	5.1	4.3	5.0	5.1	4.9	....	....	....	.....	....	....
Buttercup	Pounds of Milk	461.6	476.8	440.1	406.4	96.1	....	....	....	406.7	913.4	691.1	712.6	4,604.8	4.4	202.25	235.96
	Per cent. of Fat	4.6	4.3	4.5	4.6	6.0	....	....	....	4.6	4.3	4.1	4.2	....	.....	....	....
Prospect	Pounds of Milk	292.4	303.5	283.4	176.1	9.9	496.7	638.6	547.4	474.6	422.3	365.4	365.8	4,376.1	5.4	236.24	275.61
	Per cent. of Fat	5.3	5.4	5.3	6.6	7.4	5.3	4.9	5.3	5.6	5.3	5.4	5.6	....	.....	....	....
Daisy	Pounds of Milk	927.1	928.8	848.3	753.6	664.9	483.7	400.1	235.8	39.4	....	450.8	888.4	6,620.9	5.2	342.15	399.18
	Per cent. of Fat	5.2	5.3	5.2	4.6	5.2	5.7	5.6	6.7	5.5	....	5.0	4.6	....	.....	....	....

TABLE XI.—Continued.

Record of the Dairy Herd.

Name of cow.		April.	May.	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.	Total yield.	Average per cent. fat.	Total fat.	Equivalent to butter.
Perfection..	Pounds of Milk..............	265.1	581.2	466.5	390.7	350.4	346.5	320.6	290.3	257.2	213.9	....	....	3,482.4	4.5	157.07	183.25
	Per cent. of Fat	4.5	4.4	4.1	4.1	4.1	4.1	4.7	5.3	5.3	5.4	....	....	....	.....	....	....
Evesta, 5th..	Pounds of Milk...........	446.0	439.8	419.9	350.5	291.4	221.6	46.7	....	110.9	857.4	565.0	474.3	4,223.5	4.1	172.97	201.80
	Per cent. of Fat	3.9	4.5	4.3	4.3	4.5	4.1	3.7	....	3.7	3.8	4.0	4.1	....	.....	....	....
Cherry	Pounds of Milk	....	....	....	634.3	821.1	771.1	588.4	541.7	479.4	440.5	378.6	379.3	5,034.4	4.4	225.48	263.06
	Per cent. of Fat............	....	....	....	5.0	3.9	4.6	4.3	4.8	4.4	4.5	4.6	4.7	....	.....	....	....
Regena.......	Pounds of Milk	258.8	71.8	....	....	....	....	508.0	809.8	712.8	676.1	544.8	501.0	4,083.1	4.1	169.59	197.89
	Per cent. of Fat............	4.5	4.4	....	....	....	....	4.1	4.2	4.3	3.8	4.6	3.7	....	.....	....	....
Princessa ...	Pounds of Milk...	....	27.9	708.2	644.2	687.5	622.3	574.7	447.6	397.8	342.6	272.7	281.2	5,026.7	4.6	230.42	268.82
	Per cent. of Fat............	....	5.2	4.1	4.0	4.6	5.0	4.5	5.0	5.0	4.8	4.6	4.8	....	.....	....	....
Beauty......	Pounds of Milk	563.6	561.2	538.4	387.8	348.6	335.2	252.8	204.7	55.2	....	762.8	960.1	4,970.4	4.8	235.08	274.26
	Per cent. of Fat........	4.9	4.6	4.5	4.5	4.2	5.5	5.2	6.6	5.9	....	4.3	4.6	....	.....	....	....
Ideal	Pounds of Milk........	683.7	716.2	663.7	543.8	467.7	377.1	62.8	....	1,011.8	909.9	865.0	834.4	7,135.6	4.2	302.60	353.03
	Per cent. of Fat	4.2	4.5	4.1	4.6	4.8	6.2	7.5	....	4.4	4.1	3.8	4.1	....	.....	....	....
Queen	Pounds of Milk..............	972.1	980.2	943.2	740.3	692.2	690.4	623.0	392.3	88.6	....	....	152.7	6,275.0	4.1	257.85	299.85
	Per cent. of Fat.............	3.9	3.6	3.5	4.4	4.2	4.6	4.6	4.9	4.8	....	....	4.0	....	.....	....	....
	Average..	....	....	....	....	....	....	....	....	....	....	....	....	5,952.6	4.35	259.20	302.40

In a herd of grade cows, representing several breeds, it is natural that there should be a wide variation, both in the yield and composition of the milk produced by the individual animals. While there are two distinct classes of dairy cows, namely, milk producers and butter producers, there are also many animals of mixed breeding which combine these two characteristics in a marked degree. These points are clearly shown in the following tabulation: 1, Yields of Milk; 2, Yields of Butter; 3, Yields of Milk and Butter From Animals Which Combine in a Marked Degree the Qualities of Milk and Butter Production:

1. Yields of Milk.

1 cow..........	an average of	more than	3,000 lbs.	and less than	4,000 lbs.
6 cows.........	"	"	4,000 "	"	5,000 "
5 "	"	"	5,000 "	"	6,000 "
8 "	"	"	6,000 "	"	7,000 "
5 "	"	"	7,000 "	"	8,000 "
1 cow...........	"	"	8,000 "	"	9,000 "

The best cow produced..................	8,511.3 lbs.
The poorest cow produced....................................	3,482.4 "
Difference between highest and lowest......................	5,028.9 lbs.
Average per cow..	5,952.6 "

2. Yields of Butter.

2 cows..............	an average of	more than	150 lbs.	and less than	200 lbs.
3 "	"	"	200 "	"	250 "
7 "	"	"	250 "	"	300 "
9 "	"	"	300 "	"	350 "
4 "	"	"	350 "	"	400 "
1 cow...............	"	"	400 "	"	450 "

The best cow produced..	414.96 lbs.
The poorest cow produced...	183.25 "
Difference between highest and lowest......................	231.71 lbs.
Average per cow..	302.40 "

Fig. 8.
A crop of Barnyard Millet. Yield, 13.6 tons per acre.

3. Yields of Milk and Butter.

Name.	Breed.	Yield of Milk. lbs.	Yield of Butter. lbs.	Fat. %
Genesta	Grade Jersey	6,042	305	4.00
Daisy	" "	6,620	399	5.20
Model	" "	6,685	321	4.10
Gipsey	" "	6,729	314	4.00
Zola	" Holstein	6,976	326	4.10
Viola	" "	6,982	320	3.90
Diana	" Jersey	7,059	390	4.70
Ideal	" Holstein	7,135	353	4.20
Select	" Shorthorn	7,209	344	4.10
Pearl	" Holstein	7,282	353	4.20
Blue	" "	7,840	414	4.50
Hilda—Pure Bred	"	8,511	348	3.50

It has been shown that the cost of rations per cow per day was 11.97 cents, or a total of $43.69 per year. Following the same line of comparison, the advantages of the better cows are shown in the following:

	At 1 cent per lb.	At 3 cents per qt.	Cost of food.	Gain over Food. At 1 cent per lb.	Gain over Food. At 3 cents per qt.
Average value of product of 14 cows, yielding more than 6,000 lbs. of milk	$69 86	$96 12	$43 69	$26 17	$52 43
Average value of product of 12 cows, yielding less than 6,000 lbs. of milk	47 47	65 31	43 69	3 78	21 62
Value of product of average cow	59 53	81 51	43 69	15 84	37 82

At 1 cent per pound, the yield of the fourteen cows, producing more than 6,000 pounds of milk, is sufficient to pay for their food and $26.17, besides manure, while the average yield of the twelve cows, producing less than 6,000 pounds of milk, is sufficient to pay for their food and only $3.78, besides manure; a difference of $22.39 in favor of the better cows. At 3 cents per quart the returns from the cows yielding over 6,000 pounds of milk, over cost of food, are increased to $52.43, while the cows yielding less than 6,000 pounds are increased to $21.62, or less than one-half of those of the better cows.

As in previous years, the facts brought out by this study indicate that but little, if any, profit can be derived from a cow that

does not produce 5,000 pounds of milk per year, particularly if the milk is sold at the low price of 1 cent per pound. A very strong argument is thus presented in favor of the necessity of testing the animals and thus learning their exact value.

When butter is made, practically all the fertilizer elements in the whole milk remains upon the farm, and these, together with the skim-milk, which is estimated by careful feeders to be 20 cents per hundred, is an offset against the extra labor in making butter.

	20 cts. lbs.	Foods.	Gain over Food.
Average value of product of the 14 cows, yielding over 300 lbs. of butter	$69 20	$43 69	$25 51
Average value of product of the 12 cows, yielding less than 300 lbs. of butter	49 80	43 69	6 11
Value of product of average cow	60 48	43 69	16 79

The statement shows that the fourteen cows yielding over 300 pounds of butter paid for their food and $25.51, in addition to skim-milk and manure, while the manure and skim-milk of the twelve cows, yielding less than 300 pounds of butter, represent the pay received for their care and the labor of making the butter, with $6.11 additional. The facts brought out by the above records indicate clearly that there is but little profit from a cow that does not produce 200 pounds of butter per year, and point to the necessity of a careful selection of cows for the butter dairy.

Average Analyses of Herd Milk.

It was desired at the outset to build up a herd that would produce milk containing an average of at least 4 per cent. of butter-fat. The percentage in the herd milk has exceeded this amount each year, as shown in the following:

1897	4.25	per cent.	fat.
1898	4.41	"	"
1899	4.50	"	"
1900	4.57	"	"
1901	4.33	"	"
1902	4.39	"	"
1903	4.35	"	"

Wastes in Handling and Delivery.

A careful record has been kept of the amount of milk wasted in handling, cooling and delivery. The waste during the past seven years is shown in the following tabulation:

	Waste in Handling, Cooling and Bottling. per cent.	Waste in Delivery of Dippage. per cent.	Total Waste. per cent.
1897	5.7	5.1	10.8
1898	4.4	4.9	9.3
1899	4.8	2.0	6.0
1900	4.7	1.7	6.4
1901	3.8	1.7	5.5
1902	.8	1.2	2.0
1903	....	.16	.16

During the years 1897 and 1898 about 50 per cent. of the milk was bottled, so that the actual loss due to dippage was practically 10 per cent. of the amount handled in cans. For the past five years the proportion of milk delivered in bottles has gradually increased—in fact, since July 1st, 1902, practically all of the milk has been delivered in bottles. The .16 per cent. shown in the above table as waste in delivery and dippage represents the waste for the first three months of the past year. The waste in delivery and dippage this year since July 1st has amounted to practically nothing more than an occasional broken bottle. The tabulation also shows that there has been a decrease from year to year in the percentage of waste in handling, cooling and bottling. This is due largely to improved apparatus and greater care in handling the product. The waste from this source during the past year has amounted to that represented by an occasional accident, less than one-tenth of one per cent. While the use of bottles increases the expense of delivery, due to extra weight on the wagon, the extra work of cleaning and the breakage and loss of bottles, which amounts to about 10 cents per day for each 100 used, the decrease in waste, greater cleanliness and better condition of the milk when delivered has more than offset this extra cost.

Alfalfa Hay, Cow Pea Hay and Soy Bean Silage as Substitutes for Purchased Feeds.

Cottonseed Meal Versus Wheat Bran and Dried Brewers' Grains.

The business man aims to secure the largest return possible for every dollar expended. There is no business which requires more careful study and forethought to accomplish this than that which rests upon the dairyman when he faces the problem of providing a palatable and well-balanced ration for a dairy herd. Further, the records of progressive and unprogressive dairymen indicate that there is no business which shows a greater range of profit. The dairyman must not only be a good producer, but an intelligent buyer and careful feeder as well. These qualities become more important as the varieties of crops multiply and new feeds are added to those already in the market.

In order to study these points in a practical way, three feeding experiments were planned in which the following home-grown products and purchased feeds were used: Alfalfa hay, cow pea hay, soy bean silage, wheat bran, dried brewers' grains and cottonseed meal.

In all of the experiments the object was to study the relative value of the home-grown products and the purchased foods, and their influence upon—

I. The yield of milk,
II. The composition of milk,
III. The cost of milk and butter,
IV. The individual animals.

Experiment I.

COW PEA HAY VERSUS PURCHASED FEEDS.

The experiment began December 22d and continued through January 26th, a period of thirty-six days, including the preliminary feeding. Four cows were included in the test, divided into lots of two each. In each lot was a Holstein and a grade Jersey. At the beginning of the test the average weight of the cows in Lot I. was 1,012 pounds, and in Lot II., 917 pounds.

The Rations Used.

Cow Pea Hay Ration.

FOODS.	Dry matter.	TOTAL NUTRIENTS. Protein.	Fat.	Carbohydrates.	Estimated nutritive ratio.
	lbs.	lbs.	lbs.	lbs.	
17 pounds cow pea hay	15.75	2.37	.44	11.01	....
36 pounds corn silage	9.01	.69	.47	7.48	....
Total	24.76	3.06	.91	18.49	1:6

Feed Ration.

5 pounds cornstalks	4.27	.26	.06	3.68	....
36 pounds corn silage	9.01	.69	.47	7.48	....
4 pounds wheat bran	3.55	.63	.16	2.52	....
3 pounds dried grains	2.73	.72	.21	1.70	....
2 pounds cottonseed meal	1.85	.90	.21	.62	....
Total	21.41	3.20	1.11	16.00	1:5

As shown in the tabulation, the "feed ration" contained .14 pounds more protein and .20 pounds more fat, while the carbohydrates were 2.49 pounds greater in the "cow pea hay ration."

The nutritive ratio was estimated at 1:6 in the cow pea hay ration and 1:5 in the feed ration. The cow pea hay ration was produced entirely on the farm, while in the feed ration, over two-thirds of the most expensive nutrient, protein, was purchased.

(1) THE YIELD OF MILK AND FAT.

The milk from each cow was weighed night and morning, and aliquot samples were drawn and preserved with potassium bichromate.

Analysis was made of the composite samples thus taken, weekly. The results were uniform and the method was very simple, as compared with the immense amount of labor involved in saving a sample of each cow's milk night and morning and attempting to analyze it twice daily. Table I. shows the daily yield of milk and the composition of the "seven-day" composite samples, as well as the total yield of milk, fat and butter per cow during each period of the test. These records are given in detail in order that the reader may see exactly what the animals produced from day to day and note the effect when changes were made in the rations.

Hilda and Diana, constituting Lot I., were fed during the first period, December 25th to January 8th, inclusive, on the cow pea hay ration, and Pearl and Woodlawn were fed during the same period on the feed ration. The effect of advance of lactation, which has considerable influence upon the flow of milk, and the difference in the individuality of the animals, was equalized by reversing the rations at the close of each feeding period. After three days of preliminary feeding (January 9th to 11th, inclusive) the second period began and continued through January 26th. During this period Lot I. received the feed ration and Lot II. the cow pea hay ration. The following summary shows the total yield of milk and butter from the two rations:

TABLE I.

DATE.	Lot I.—First Period. Cow Pea Hay Ration.						Lot II.—First Period. Feed Ration.					
	HILDA.			DIANA.			PEARL.			WOODLAWN.		
	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.
	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	%	lbs.
December 25, 1902	25.5	......	....	19.2	......	....	29.4	......	....	21.0	......	....
" 26, "	25.1	......	....	18.5	......	....	30.5	......	....	21.2	......	....
" 27, "	25.3	......	....	18.6	......	....	31.3	......	....	20.4	......	....
" 28, "	25.8	......	....	20.5	......	....	30.1	......	....	21.7	......	....
" 29, "	25.0	3.9	4.94	21.0	4.6	4.50	29.5	3.9	5.88	22.2	4.3	4.58
" 30, "	25.0	......	....	21.6	......	....	30.0	......	....	22.2	......	....
" 31, "	25.5	......	....	21.8	......	....	30.8	......	....	21.7	......	....
January 1, 1903	25.5	......	....	21.5	......	....	31.6	......	....	24.8	......	....
" 2, "	27.4	......	....	21.0	......	....	30.8	......	....	22.5	......	....
" 3, "	26.9	3.5	4.56	21.3	4.2	4.50	30.6	3.8	5.84	21.5	4.1	4.62
" 4, "	25.1	......	....	21.1	......	....	29.4	......	....	22.5	......	....
" 5, "	25.2	......	....	21.2	......	....	31.3	......	....	23.0	......	....
" 6, "	25.3	......	....	21.8	......	....	32.5	......	....	23.6	......	....
" 7 "	25.3	......	....	21.1	......	....	32.0	......	....	23.0	......	....
" 8, "	25.8	3.5	4.43	20.8	4.3	4.56	30.3	4.0	6.22	22.8	4.4	5.06
Total	383.7	......	13.93	311.0	......	13.56	460.1	......	17.94	334.1	......	14.26
Average	25.6	3.63	4.64	20.7	4.36	4.52	30.7	3.90	5.98	22.3	4.27	4.75

DATE.	Lot I.—Second Period. Feed Ration.						Lot II.—Second Period. Cow Pea Hay Ration.					
January 12, 1903	26.5	......	....	24.3	......	....	30.5	......	....	20.8	......	....
" 13, "	28.0	......	....	22.5	......	....	29.1	......	....	19.8	......	....
" 14, "	27.7	......	....	22.0	......	....	28.0	......	....	19.8	......	....
" 15, "	27.3	......	....	22.6	......	....	28.1	......	....	20.1	......	....
" 16, "	27.3	3.8	5.20	22.6	4.7	5.36	28.5	3.7	5.34	19.5	3.8	3.80
" 17, "	25.0	......	....	21.8	......	....	29.0	......	....	18.3	......	....
" 18, "	26.0	......	....	21.7	......	....	28.1	......	....	19.6	......	....
" 19, "	25.4	......	....	23.5	......	....	29.4	......	....	19.3	......	....
" 20, "	26.6	......	....	23.2	......	....	28.0	......	....	20.0	......	....
" 21, "	27.6	3.8	4.96	23.5	4.7	5.34	29.0	3.7	5.31	19.0	3.9	3.75
" 22, "	28.3	......	....	24.5	......	....	28.3	......	....	20.5	......	....
" 23, "	27.7	......	....	22.1	......	....	27.7	......	....	19.8	......	....
" 24, "	27.3	......	....	21.8	......	....	29.0	......	....	20.2	......	....
" 25, "	26.4	......	....	21.7	......	....	26.1	......	....	20.2	......	....
" 26, "	26.5	3.6	4.90	23.4	4.7	5.33	28.7	3.8	5.31	22.0	3.8	3.90
Total	403.6	......	15.06	341.2	......	16.03	427.5	......	15.96	298.9	......	11.45
Average	26.9	3.73	5.02	22.7	4.70	5.38	28.5	3.73	5.32	19.9	3.83	3.81

TABLE II.

Summary of the Experiment.

	COW PEA HAY RATION.				FEED RATION.			
	Milk.	Fat.	Fat.	Butter.	Milk.	Fat.	Fat.	Butter.
Lot I.	lbs.	%	lbs.	lbs.	lbs.	%	lbs.	lbs.
Hilda	383.7	3.63	13.93	16.25	403.6	3.73	15.06	17.57
Diana	311.0	4.36	13.56	15.82	341.2	4.70	16.C3	18.70
Total	694.7	3.96	27.49	32.07	744.8	4.17	31.09	36.27
Lot II.								
Pearl	427.5	3.73	15.96	18.62	460.1	3.90	17.94	20.93
Woodlawn	298.9	3.83	11.45	13.36	334.1	4.27	14.26	16.64
Total	726.4	3.77	27.41	31.98	794.2	4.05	32.20	37.57
Total	1,421.1	....	54.90	64.05	1,539.0	....	63.29	73.84
Daily average per cow	23.7	3.86	.92	1.07	25.7	4.11	1.05	1.23

The summary shows that 117.9 pounds, or 8.3 per cent. more milk, and 9.79 pounds, or 15.2 per cent. more butter, were produced from the feed ration than from the cow pea hay ration.

(2) THE COMPOSITION OF THE MILK.

A study of the summary indicates that the composition of the milk was slightly influenced when the animals were changed from one ration to the other. The following shows the composition of the milk from each animal when fed the different rations:

TABLE III.

	Cow pea hay ration—per cent. fat.	Feed ration—per cent. fat.
Hilda	3.63	3.73
Diana	4.36	4.70
Pearl	3.73	3.90
Woodlawn	3.83	4.27
Average	3.86	4.11

It is noticeable that all the cows tested higher when fed the "feed ration." This may have been due, in part, at least, to the periods being comparatively short (fifteen days). It has been shown in other experiments that changes in rations frequently produce a temporary effect upon the content of fat in milk, causing an increase or decrease, and that after a few weeks it returns again to its normal percentage.

(3) THE COST OF MILK AND BUTTER FROM THE TWO RATIONS.

The cost of producing milk and butter from the two rations has been calculated, using as a basis the market prices of the feeds at the time of the experiment, and the actual cost of the coarse foods, which were produced on the farm. The cottonseed meal, wheat bran and dried brewers' grains were purchased for $30, $21 and $20 per ton, respectively, while the cow pea hay, cornstalks and corn silage cost at the rate of $6, $4 and $2.40 per ton.

TABLE IV.

The Food Consumed and the Yield and Cost of the Milk and Butter Produced.

	Number of days.	FOOD CONSUMED PER COW DAILY.						Cost of ration.	YIELD OF—		COST TO PRODUCE.	
		Corn silage.	Cornstalks.	Cow pea hay.	Wheat bran.	Dried grain.	Cottonseed meal.		Milk.	Butter.	100 lbs. milk.	1 lb. butter.
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	cts.	lbs.	lbs.	cts.	cts.
Cow Pea hay ration	30	36	......	17	......	......	......	9.42	1,421.1	64.05	39.80	8.82
Feed ration	30	36	5	......	4	3	2	15.52	1,539.0	73.84	60.51	12.60

The cost of food used to produce 100 pounds of milk and one pound of butter is shown to be 39.8 cents and 8.82 cents, respectively, for the cow pea hay ration and 60.5 cents and 12.6 cents for the feed ration. A comparison of the value of the two rations is given in the following:

	Milk Produced. lbs.	Cost per Hundred. cts.	Total Cost.	Value at $1 per Hundred.	Difference Between Cost and Selling Prices.
Cow pea hay ration	1,421.1	39.8	$5.65	$14.21	$8.56
Feed ration	1,539.0	60.5	9.31	15.39	6.08

While 117.9 pounds more milk was produced from the feed ration, the tabulation shows that this increase was not enough to offset the greater cost of production, hence the cow pea hay ration proved the more profitable. The gain from the cow pea and feed rations over the cost of foods when milk is worth $1 per hundred is shown to be $8.56 and $6.08, respectively, a difference of $2.48 for two cows for the period of thirty days in favor of the cow pea hay ration. Applying these results to a herd of thirty cows, the gain from feeding the cow pea hay ration over the feed ration would amount to $37.20 per month.

The results show further that if we had purchased the cow pea hay in the market instead of raising it on the farm, we could afford to pay $11.75 per ton for it when the fine feeds used were selling at the prices already quoted.

Fig. 20.
A field of Cow Pea Hay.

(4) THE INDIVIDUAL ANIMALS.

The weights of the cows were taken at the beginning and close of each test. The following tabulation shows the weights at the close of the feeding tests with the different rations:

	Cow Pea Hay Ration. lbs.	Feed Ration. lbs.
Hilda—Pure Bred Holstein	1,005	950
Diana—Grade Jersey	965	950
Pearl—Grade Holstein	975	975
Woodlawn—Grade Jersey	845	845
Total	3,790	3,720
Average	947	930

The above shows that Hilda and Diana both lost in weight on the feed ration, while Pearl and Woodlawn maintained the same weight on both rations. The average for all the cows throughout the tests shows a gain of seventeen pounds in favor of the cow pea hay ration. From the standpoint of the health of the animals, therefore, this ration, which was much cheaper, proved superior, to the more costly one.

How the Cow Pea Crop Was Handled.

The cow peas were cut with a mowing machine and allowed to wilt thoroughly. This required two days. They were then raked in wind-rows and placed in small cocks made narrow and about the same diameter throughout in order to insure an even cure. The hay remained in these cocks for five days. The cocks were then turned over for a couple of hours to dry the bottoms, which had taken up moisture from the soil. The hay was then hauled to the barn in excellent condition. The leaves retained their green color and nearly all were preserved. The hay, even at this time, felt a little damp to the touch, and to one who had never had experience with the crop, it doubtless would have appeared unfit to store, but it saved perfectly and was eaten greedily by the animals in the test with scarcely any waste. An average crop of cow peas showed a yield of 2½ tons per acre.

General Remarks Upon the Results of the Experiment.

It is interesting to note that a ration composed wholly of what may be termed "coarse foods" proved nearly equal in value as a milk and butter producer to one which contained nine pounds of "fine feeds" in combination with the coarser foods.

It is also of interest to note that milk from the cow pea hay ration was produced for 20.7 cents less per hundred and that butter was produced for 4.4 cents less per pound than from the feed ration, and that the cow pea hay ration cost 6.1 cents less per day. However, it is believed that a combination of *coarse* and *fine* feeds is necessary to produce the best results. In other words, there is a happy medium between the two extremes as represented by the rations considered. Suppose, for example, the dairyman has a large supply of coarse food which he wishes to utilize; a combination can be made of this with, say four or five pounds of fine feeds of such a character as will properly balance the ration, thus reducing its bulk and supplying a part of the nutrients in a readily digestible form. If the coarse food be of a starchy character, as cornstalks, silage, timothy hay, etc., cottonseed meal can be utilized to advantage. On the other hand, if the coarse food is rich in protein, as is the case with cow pea hay, crimson clover hay, soy bean silage, etc., then corn meal will supply the starchy substance. This suggestion is carried out in Experiment III., page 402.

Experiment II.

SOY BEAN SILAGE AND ALFALFA HAY VERSUS PURCHASED FEEDS.

It was the purpose of this experiment to compare the value of a ration that could readily be grown upon the farm with one in which the protein was largely supplied by feeds commonly purchased by dairymen, namely, wheat bran, dried brewers' grains and cottonseed meal. This experiment was similar to experiment No. 1 in respect to the number of cows used and the length of time covered by the test.

The experiment began February 2d and continued through March 8th. The cows Viola and Hilda constituted Lot I., while Ideal and Luella were included in Lot II. The animals, four in number, averaged 966 pounds live weight and were fed for thirty days in periods of fifteen days each on the following rations:

The Rations Used in the Experiment.

Ration I.—Soy Bean Silage and Alfalfa Hay Ration.

FOODS.	Dry matter.	TOTAL NUTRIENTS. Protein.	Fat.	Carbohydrates.	Estimated nutritive ratio.
	lbs.	lbs.	lbs.	lbs.	lbs.
36 pounds soy bean silage	9.03	1.61	.53	5.44	....
8 pounds alfalfa hay	7.45	1.48	.23	5.02	....
6 pounds corn meal	5.23	.55	.24	4.35	....
Total	21.71	3.64	1.00	14.81	1:5

Ration II.—Feed Ration.

6 pounds cornstalks	5.12	.31	.07	4.41	....
36 pounds corn silage	9.01	.69	.47	7.48	....
4 pounds wheat bran	3.55	.63	.16	2.52	....
4 pounds dried grains	3.66	.97	.28	2.07	....
2 pounds cottonseed meal	1.85	.85	.25	.60	....
Total	23.19	3.45	1.23	17.08	1:6

It was planned to have each ration contain as near as practicable the same amount of total protein. The amount of milk obtained, therefore, other things being equal, would serve to compare the relative value of the protein in the two rations. The analyses of all the foods used when the experiment began were not completed, but a careful estimate was made of the protein in the two rations, which was found to agree very closely with the actual. As shown in the table, ration I. contained 3.64 pounds of protein and ration II., 3.45 pounds. The fat and carbohydrates, however, were somewhat greater in ration II., and it is questionable whether this surplus was favorable or unfavorable to the milk production, as ration I., containing a much smaller amount of these nutrients, proved the heaviest producer. This point is brought out more clearly later in the discussion.

During the first period, Lot I. was fed the commercial feed ration and Lot II. the alfalfa and soy bean silage. Lot I. was fed during the second period on the alfalfa and soy bean silage ration, and Lot II. on the feed ration. The rations were reversed for the purpose of equalizing the effect of advance in lactation, as well as any difference in the individuality of the animals and their ability to utilize the different foods.

1. The Yield of Milk and Fat.

The milk from each cow was weighed night and morning and aliquot samples were drawn and preserved with potassium bi-chromate for the Babcock test, which was made weekly. Table V. shows the daily yield of milk and the average weekly composition, as well as the total yield of milk and fat for the different periods of the test.

TABLE V.

Date.	Lot I.—First Period. Feed Ration.						Lot II.—Second Period. Alfalfa and Soy Bean Ration.					
	Viola.			Hilda.			Ideal.			Luella.		
	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.
	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	%	lbs.
February 2, 1903	24.5	......	....	29.5	......	....	32.7	......	....	26.0	......	....
" 3, "	22.8	......	....	29.3	......	....	34.1	......	....	27.5	......	....
" 4, "	24.5	......	....	30.3	......	....	33.4	......	....	25.5	......	....
" 5, "	23.6	3.9	4.66	29.5	......	....	32.8	......	....	27.0	......	....
" 6, "	24.0	......	....	28.5	3.6	5.30	31.4	3.5	5.75	26.8	3.5	4.65
" 7, "	24.3	......	....	28.3	......	....	33.6	......	....	26.1	......	....
" 8, "	25.0	......	....	29.3	......	....	32.7	......	....	26.8	......	....
" 9, "	23.8	......	....	29.0	......	....	34.1	......	....	26.6	......	....
" 10, "	23.5	......	....	27.6	......	....	32.1	......	....	26.8	......	....
" 11, "	23.2	3.9	4.67	28.3	3.6	5.13	29.9	3.8	6.17	26.5	3.3	4.38
" 12, "	24.5	......	....	28.0	......	....	29.8	......	....	25.3	......	....
" 13, "	23.1	......	....	27.9	......	....	32.0	......	....	24.6	......	....
" 14, "	23.0	......	....	26.0	......	....	31.5	......	....	24.6	......	....
" 15, "	23.3	......	....	26.7	......	....	30.5	......	....	24.5	......	....
" 16, "	23.0	3.8	4.44	27.0	3.6	4.88	31.7	3.7	5.75	24.5	3.6	4.45
Total	356.1	......	13.77	425.2	......	15.31	482.3	......	17.67	389.1	......	13.48
Average	23.7	3.87	4.58	28.3	3.60	5.10	32.1	3.66	5.89	25.9	3.46	4.49

Date.	Lot I.—Second Period. Alfalfa and Soy Bean Ration.						Lot II.—Second Period. Feed Ration.					
February 22, 1903	22.0	......	....	29.0	......	....	29.2	......	....	23.3	......	....
" 23, "	22.0	......	....	29.8	......	....	31.0	......	....	24.8	......	....
" 24, "	22.6	......	....	29.0	......	....	29.0	......	....	25.1	......	....
" 25, "	23.2	......	....	28.8	......	....	28.6	......	....	22.3	......	....
" 26, "	23.2	3.7	4.18	29.0	3.6	5.24	28.4	4.1	5.99	24.4	3.9	4.68
" 27, "	23.7	......	....	28.5	......	....	26.9	......	....	24.9	......	....
" 28, "	23.0	......	....	26.6	......	....	25.9	......	....	25.2	......	....
March 1, "	22.1	......	....	28.6	......	....	25.0	......	....	23.7	......	....
" 2, "	22.7	......	....	27.0	......	....	24.1	......	....	23.4	......	....
" 3, "	23.0	3.6	4.12	27.8	3.8	5.26	23.9	4.2	5.28	24.7	3.8	4.63
" 4, "	23.4	......	....	28.0	......	....	24.5	......	....	24.0	......	....
" 5, "	22.8	......	....	26.3	......	....	25.0	......	....	24.3	......	....
" 6, "	23.6	......	....	26.0	......	....	27.0	......	....	24.2	......	....
" 7, "	22.8	......	....	26.2	......	....	26.0	......	....	23.6	......	....
" 8, "	24.0	3.6	4.20	28.0	3.5	4.71	26.7	3.7	4.78	24.0	3.6	4.32
Total	344.1	......	12.50	418.6	......	15.21	401.2	......	16.05	361.9	......	13.63
Average	22.9	3.63	4.17	27.9	3.63	5.07	26.7	4.00	5.35	24.1	3.77	4.54

TABLE VI.

Summary of the Experiment.

	Ration I. Soy bean silage and alfalfa hay.				Ration II. Purchased feeds.			
	Milk.	Fat.	Fat.	Butter.	Milk.	Fat.	Fat.	Butter.
Lot I.	lbs.	%	lbs.	lbs.	lbs.	%	lbs.	lbs.
Viola	344.1	3.63	12.50	14.58	356.1	3.87	13.77	16.07
Hilda	418.6	3.63	15.21	17.75	425.2	3.60	15.31	17.86
Total	762.7	3.63	27.71	32.33	781.3	3.72	29.08	33.93
Lot II.								
Ideal	482.3	3.66	17.67	20.62	401.2	4.00	16.05	18.73
Luella	389.1	3.46	13.48	15.73	361.9	3.77	13.63	15.90
Total	871.4	3.57	31.15	36.35	763.1	3.88	29.68	34.63
Total	1,634.1	....	58.86	68.57	1,544.4	....	58.76	68.55
Daily average per cow	27.2	3.60	.98	1.14	25.7	3.80	.98	1.14

The amount of milk produced by the soy bean silage and alfalfa hay ration was 1,634.1 pounds, or 89.7 pounds (5.81 per cent.) more than that produced by the feed ration. The yield of butter from the two rations was practically the same, namely, 68.67 and 68.55 pounds, respectively. The percentage of butter-fat averaged 3.60 and 3.80. There was, therefore, a difference of .2 per cent.; so light a difference was probably due fully as much to natural variations as to the effect of foods.

These results show that it is practicable from the standpoint of milk and butter production to grow the entire ration upon the farm. The cost of milk and butter from the two rations will now be considered. In calculating this cost, the food grown on the farm is figured at the actual cost of production, namely, $2.40 per ton for corn silage, $3 for soy bean silage, $5.50 for alfalfa hay and $4 for cornstalks. Corn meal, which might readily be grown on most farms, was purchased in this case; therefore, it is calculated in the ration at the purchase price, $26 per ton. The other purchased feeds used and their cost were as follows: Wheat bran, $21 per ton; dried brewers' grains, $20, and cottonseed meal, $30.

The Food Consumed and the Yield and Cost of the Milk and Butter Produced.

	Number of days.	FOOD CONSUMED PER COW PER DAY.								Cost of ration	YIELD OF—		COST TO PRODUCE.	
		Alfafa hay.	Soy bean silage.	Corn silage.	Cornstalks	Corn meal.	Wheat bran.	Dried grains	Cottonseed meal.		Milk.	Butter.	100 lbs. milk.	1 lb. butter.
		lbs.	lbs.	lbs.	lbs.	lbs	lbs.	lbs.	lbs.	cts.	lbs.	lbs.	cts.	cts.
Soy bean silage and alfafa hay ration...	30	8	36	.....	......	6	......	......	......	15.40	1,634.1	68.67	56.5	13.5
Feed ration	30	......	......	36	6	......	4	4	2	16.72	1,544.4	68.55	65.0	14.6

The above table shows the cost of foods used to produce 100 pounds of milk and one pound of butter from the two rations to be 56.5 cents and 13.5 cents, respectively, for the soy bean silage and alfalfa hay ration, and 65 cents and 14.6 cents for the feed ration. There was, therefore, a saving of 8.5 cents per hundred in the cost of producing milk and 1.1 cents per pound in the production of butter when the soy bean silage and alfalfa hay ration was fed.

It should be noted further that the corn meal was purchased at a cost of $26 per ton. This could readily be produced on many farms for much less than this price, therefore offering a further advantage for the ration in which this was employed.

These data are significant in showing not only the value of such home-grown crops as soy bean silage and alfalfa hay, but also that a ration may be produced on the farm that is quite superior as a milk producer to one in which the fine feeds are purchased; at the same time it is furnished at less cost.

The weights of the cows in this experiment averaged 965 pounds for the alfalfa hay and soy bean ration and 931 pounds for the feed ration.

Notes on Fodders Used in the Experiment.

The soy beans used for silage in this experiment were cut just as the pods were forming and run through an ensilage cutter, and placed in the silo without being mixed with any other crop. The silage had a penetrating odor, but was perfectly pre-

served, the leaves and stems retaining their natural form. The thirty-six pounds of silage, combined with eight pounds of alfalfa hay, was greedily eaten by the cows in the test. The yield of green soy beans ranges from six to ten tons per acre, depending upon the season. It was thought that the soy bean silage, because of its penetrating odor, might have some influence upon the flavor and keeping quality of the milk. A test was therefore made by keeping the milk in ordinary milk bottles, well capped and placed in spring water at a temperature of 48 degrees F. The milk was tested for flavor by one or more persons daily, and up to the fifth day it was pronounced a first-class article. Although the experiment with soy bean silage was a success from practically every standpoint, at the same time it is believed that as much food value can be obtained from the soy bean crop and probably at a less cost by preserving it in the form of hay. This may also be said of cow peas.

A five-year experiment with one acre of alfalfa has demonstrated that the crop can be made to yield an average of 19.32 tons of green forage per year (including the first year), equivalent to 4.83 tons of hay, costing an average of $5.50 per ton. We can highly recommend this plant for either forage or hay.

Experiment III.

COTTONSEED MEAL VERSUS WHEAT BRAN AND DRIED BREWERS' GRAINS.

The plan of this experiment was the same as the one first described. The object was to compare cottonseed meal with wheat bran and dried grains in respect to its milk-producing quality. The amount of protein in the rations from these two sources was made practically the same, the cottonseed meal supplying 2.02 pounds and the bran and grains 1.99 pounds.

The first and second periods of the experiment extended from December 25th through January 26th—thirty-three days—including the preliminary feeding. The same experiment was then duplicated with four other cows, which will be referred to as the third and fourth periods. The four periods will be considered together in discussing the results. As already stated, four cows were included in the tests, divided into lots of two each.

The Rations Used.

No. I.—Cottonseed Meal Ration.

FOODS.	Dry matter.	TOTAL NUTRIENTS. Protein.	Fat.	Carbohydrates.	Estimated nutritive ratio.
	lbs.	lbs.	lbs.	lbs.	
36 pounds corn silage	9.01	.69	.47	7.48	....
6 pounds cornstalks	4.27	.26	.C6	3.68	....
4.5 pounds cottonseed meal	4.16	2.02	.46	1.39	....
Total	17.44	2.97	.99	12.55	1:5.1

No. II.—Bran and Dried Brewers' Grains Ration.

36 pounds corn silage	9.01	.69	.47	7.48	....
6 pounds cornstalks	4.27	.26	.06	3.68	....
5 pounds wheat bran	4.44	.79	.21	3.15	....
5 pounds dried grains	4.56	1.20	.35	2.83	....
Total	22.28	2.91	1.09	17.14	1:6.7

It is shown that the two rations supplied practically the same amount of protein, while the dry matter, fat and carbohydrates were somewhat greater in the bran and grains ration. The estimated nutritive ratio for the rations was 1:5.1 for No. I. and 1:6.7 for No. II.

I. The Yield of Milk and Fat.

The milk from each cow was weighed night and morning and aliquot samples were drawn and preserved with potassium bi-chromate for the Babcock test, which was made weekly. Table VII. shows the daily yield of milk and the average weekly composition, as well as the total yield of milk and fat for the different periods of the test.

TABLE VII.

Lot I.—First Period. Bran and Grains Ration. **Lot II.—Second Period. Cottonseed Meal Ration.**

DATE.	ALTA. Milk.	ALTA. Fat.	ALTA. Fat.	IDEAL. Milk.	IDEAL. Fat.	IDEAL. Fat.	LUELLA. Milk.	LUELLA. Fat.	LUELLA. Fat.	REGENA. Milk.	REGENA. Fat.	REGENA. Fat.
	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	%	lbs.
December 25, 1902	18.0	......	....	34.6	......	....	26.1	......	....	20.6	......	....
" 26, "	19.1	......	....	33.5	......	....	25.5	......	....	20.0	......	....
" 27, "	18.2	......	....	31.8	......	....	24.4	......	....	20.3	......	....
" 28, "	18.1	......	....	31.5	......	....	24.3	......	....	19.8	......	....
" 29, "	19.2	4.4	4.07	32.6	4.0	6.56	26.2	3.9	4.93	21.2	4.0	4.08
" 30, "	18.9	......	....	33.2	......	....	27.0	......	....	21.3	......	....
" 31, "	17.9	......	....	35.0	......	....	26.6	......	....	21.6	......	....
January 1, 1903	18.8	......	....	31.1	......	....	26.8	......	....	24.1	......	....
" 2, "	16.7	......	....	33.1	......	....	25.2	......	....	22.0	......	....
" 3, "	*13.0	4.4	3.75	31.1	3.9	6.38	26.9	3.7	4.90	21.5	3.9	4.31
" 4, "	16.7	......	....	32.7	......	....	26.5	......	....	19.4	......	....
" 5, "	16.5	......	....	30.6	......	....	26.5	......	....	21.9	......	....
" 6, "	18.0	......	....	33.7	......	....	27.1	......	....	21.6	......	....
" 7, "	17.2	......	....	33.8	......	....	27.4	......	....	22.0	......	....
" 8, "	16.1	4.4	3.72	31.4	3.9	6.33	26.3	3.5	4.68	21.0	3.9	4.14
Total	262.4	......	11.54	489.7	......	19.27	392.8	......	14.51	318.5	......	12.53
Average	17.5	4.40	3.84	32.6	3.94	6.42	26.8	3.69	4.83	21.2	3.93	4.18

Lot I.—Second Period. Cottonseed Meal Ration. **Lot II.—Second Period. Bran and Grains Ration.**

DATE.	ALTA. Milk.	ALTA. Fat.	ALTA. Fat.	IDEAL. Milk.	IDEAL. Fat.	IDEAL. Fat.	LUELLA. Milk.	LUELLA. Fat.	LUELLA. Fat.	REGENA. Milk.	REGENA. Fat.	REGENA. Fat.
January 12, 1903	17.8	......	....	28.7	......	....	28.9	......	....	23.0	......	....
" 13, "	17.3	......	....	27.5	......	....	28.8	......	....	22.9	......	....
" 14, "	17.1	......	....	26.0	......	....	29.3	......	....	21.0	......	....
" 15, "	17.5	......	....	27.0	......	....	29.1	......	....	22.5	......	....
" 16, "	18.0	4.6	4.03	26.8	4.5	6.12	26.5	3.5	4.99	21.5	3.4	3.77
" 17, "	17.4	......	....	27.0	......	....	25.5	......	....	21.0	......	....
" 18, "	17.5	......	....	26.8	......	....	26.6	......	....	20.5	......	....
" 19, "	17.1	......	....	25.3	......	....	25.9	......	....	22.3	......	....
" 20, "	16.2	......	....	26.1	......	....	25.4	......	....	20.8	......	....
" 21, "	18.0	4.6	3.97	28.3	4.2	5.61	27.5	3.7	4.94	22.0	3.6	3.84
" 22, "	18.6	......	....	26.1	......	....	27.8	......	....	21.7	....	....
" 23, "	17.0	......	....	25.9	......	....	26.3	......	....	21.7	......	....
" 24, "	17.1	......	....	24.3	......	....	26.4	......	....	20.9	......	....
" 25, "	16.5	......	....	25.6	......	....	25.5	......	....	21.8	......	......
" 26, "	17.6	4.7	4.08	27.3	4.3	5.56	27.0	3.6	4.79	21.7	3.7	3.99
Total	260.7	......	12.08	398.7	....	17.29	406.5	......	14.72	325.3	......	11.60
Average	17.4	4.63	4.03	26.6	4.34	5.76	27.1	3.62	4.91	21.7	3.57	3.87

* Cow not eating well.

TABLE VII.—Continued.

Lot I.—Third Period. Bran and Grains Ration. **Lot II.—Third Period. Cottonseed Meal Ration.**

DATE.	DIANA.			PEARL.			HAZEL.			BUTTERCUP.		
	Milk.	Fat.	Fat.	Milk.	Fat.	Fat.	Milk.	Fat	Fat.	Milk.	Fat.	Fat.
	lbs.	%	lbs.	lbs.	%	lbs.	lbs.	%	lbs.	lbs	%	lbs.
February 2, 19 3	22.7	......	....	26.7	......	....	19.2	.....	....	28.0	.. ..	....
" 3, "	21.2	......	....	26.2	......	....	20.0	.....	....	27.1	......	....
" 4, "	23.0	......	....	27.5	......	....	20.0	.....	....	26.7	......	....
" 5, "	22.2	......	....	25.0	......	....	19.0	.....	....	25.3	......	....
" 6, "	22.5	4.5	5.02	27.1	3.7	4.90	19.3	4.6	4.49	25.7	4.3	5.71
" 7, "	22.5	......	....	26.6	......	....	20.2	.....	....	25.8	......	....
" 8, "	22.5	......	....	25.0	......	....	19.8	......	....	26.2	......	....
" 9, "	23.5	......	....	26.0	......	....	20.4	......	....	26.6	......	....
" 10, "	23.3	......	....	26.3	.....	....	19.0	......	....	25.6	......	....
" 11, "	23.4	4.6	5.30	25.2	3.8	4.91	18.7	4.4	4.32	24.8	4.3	5.55
" 12, "	21.5	.....	....	25.7	......	....	21.2	......	....	25.1	......	....
" 13, "	22.7	......	....	25.3	......	....	19.2	......	....	25.1	......	....
" 14, "	22.5	......	....	25.5	......	....	18.3	......	....	24.2	......	....
" 15, "	22.5	......	....	26.4	......	....	18.5	......	....	23.5	......	....
" 16, "	23.0	4.4	4.94	25.8	3.9	5.02	19.2	4.5	4.34	23.9	4.3	5.24
Total	339.0	......	15.26	390.3	......	14.83	292.0	......	13.15	383.6	......	16.50
Average	22.6	4.50	5.09	26.0	3.80	4.94	19.4	4.50	4.38	25.6	4.30	5.50

Lot I.—Fourth Period. Cottonseed Meal Ration. **Lot II.—Fourth Period. Bran and Grains Ration.**

DATE.	DIANA Milk lbs.	Fat %	Fat lbs.	PEARL Milk lbs.	Fat %	Fat lbs.	HAZEL Milk lbs.	Fat %	Fat lbs.	BUTTERCUP Milk lbs.	Fat %	Fat lbs.
February 20, 1903	21.1	......	....	24.0	......	....	20.0	......	....	23.5	.....	....
" 21, "	19.5	......	....	24.8	......	....	19.5	.....	....	24.5	.....	....
" 22, "	21.0	.....	....	24.0	......	....	19.2	......	....	22.5	......	....
" 23, "	20.6	......	....	24.3	......	....	19.4	.....	....	24.1	.....	....
" 24, "	20.8	4.7	4.84	25.0	3.9	4.76	21.0	4.2	4.16	24.7	3.8	4.53
" 25, "	21.4	......	....	24.9	.....	....	20.9	.....	....	23.0	.....	....
" 26, "	20.2	......	....	23.7	.....	....	20.2	......	....	23.1	.....	....
" 27, "	20.6	......	....	23.5	......	....	20.8	.....	....	22.5	.....	....
" 28, "	21.1	......	....	23.9	......	....	21.1	.....	....	23.8	.....	....
March 1, "	21.1	4.7	4.91	23.5	4.1	4.90	21.7	4.3	4.50	23.5	4.0	4.64
" 2, "	22.1	......	....	22.9	......	....	18.9	......	....	22.9	......	....
" 3, "	20.2	......	....	23.7	......	....	19.2	.....	....	23.2	.....	....
" 4, "	22.2	......	....	24.3	......	....	20.2	......	....	22.5	.....	....
" 5, "	20.5	......	....	22.5	.....	....	20.7	.....	....	22.4	.....	....
" 6, "	20.6	4.6	4.86	25.0	3.9	4.62	20.7	4.4	4.39	23.1	4.0	4.56
Total	313.0	......	14.61	360.0	......	14.28	303.5	......	13.05	349.3	.....	13.73
Average	20.9	4.67	4.87	24.0	3.97	4.76	20.2	4.30	4.35	23.3	3.93	4.58

Alta and Ideal, constituting Lot I., were fed during the first period of the test, December 25th to January 8th, inclusive, on the bran and grains ration, and Luella and Rejena were fed during the same period on the cottonseed meal ration. The rations were then reversed (January 8th) for reasons already stated, and, beginning January 12th and continuing through January 26th, Lot I. received the cottonseed meal ration and Lot II. the bran and grains ration. Four other cows were substituted for the third and fourth periods of the test previously described. The third period extended from February 2d through February 16th, when the rations were reversed. The fourth period began February 20th and extended through March 6th. The following summary shows the total yield of milk and fat for the two rations during the four periods:

Summary of the Experiments.

	RATION I. COTTONSEED MEAL RATION.				RATION II. BRAN AND GRAINS RATION.			
	Milk.	Fat.	Fat.	Butter.	Milk.	Fat.	Fat.	Butter.
First Test—Lot I.	lbs.	%	lbs.	lbs	lbs.	%	lbs.	lbs.
Alta	260.7	4.63	12.08	14.09	262.4	4.40	11.54	13.46
Ideal	398.7	4.34	17.29	20.17	489.7	3.94	19.27	22.48
Lot II.								
Luella	392.8	3.69	14.51	16.93	406.5	3.62	14.72	17.17
Regina	318.5	3.93	12.53	14.62	325.3	3.57	11.60	13.53
Total	1,370.7	4.12	56.41	65.81	1,483.9	3.85	57.13	66.64
Second Test.—Lot III.								
Diana	313.0	4.67	14.61	17.04	339.0	4.50	15.26	17.00
Pearl	360.0	3.97	14.28	16.66	390.3	3.80	14.83	17.30
Lot IV.								
Hazel	292.0	4.50	13.15	15.34	303.5	4.30	13.05	15.23
Buttercup	383.6	4.30	16.50	19.25	349.3	3.93	13.73	16.02
Total	1,348.6	4.34	58.54	68.29	1,382.1	4.11	56.87	66.35
Total	2,719.3	....	114.95	134.10	2,866.0	....	114.00	132.99
Daily average per cow	22.7	4.23	0.96	1.12	23.9	3.98	.95	1.11

The summary shows that the amount of milk and butter produced from the two rations was practically the same, ration I. producing 2,719.3 pounds of milk and 134.1 pounds of butter, and ration II. 2,866 pounds of milk and 132.99 pounds of butter, a difference of 146.7 pounds of milk in favor of the bran and grains ration, and .95 pounds of butter in favor of the cottonseed meal ration.

The average percentage of fat is shown to be 4.23 per cent. for ration I. and 3.98 for ration II., a difference of .25 per cent. in favor of the cottonseed meal ration.

The results are very favorable for both rations as milk-producers, but a more important consideration is the cost of milk and butter from the two rations.

The Cost of Milk and Butter.

As in the first experiment, the cost of roughage was placed at the actual cost of production, namely, $2.40 per ton for silage and $4 per ton for cornstalks. The cost of the purchased feeds was $20 per ton for dried grains, $21 for wheat bran and $30 for cottonseed meal.

TABLE VIII.

The Food Consumed and the Yield and Cost of the Milk and Butter Produced.

	Number of days.	FOOD CONSUMED PER DAY PER COW.					Cost of ration.	YIELD OF—		COST TO PRODUCE	
		Corn silage	Cornstalks.	Wheat bran.	Dried grains.	Cottonseed.		Milk.	Butter.	100 lbs milk.	1 lb. butter.
		lbs	lbs.	lbs	lbs	lbs.	cts.	lbs.	lbs.	cts.	cts.
Cottonseed meal ration	60	36	6	......	....	4.5	12.27	2,719.3	134.10	54.1	11.0
B:an and grains ration	60	36	6	5	5	......	15.77	2,866.0	132.99	66.0	14.3

The cost of foods used to produce 100 pounds of milk and one pound of butter from the two rations was 54.1 cents and 11 cents, respectively, for the cottonseed meal ration and 66 cents and 14.3 cents, for the bran and grains ration. There was, therefore,

a saving of 11.9 cents per hundred in the cost of production of milk and 3.3 cents per pound in the cost of producing butter, when the cottonseed meal was fed. In other words, the results indicate that when dried grains cost $20 and wheat bran $21 per ton, the dairyman can afford to pay $42 per ton for cottonseed meal when producing milk.

A comparison of the value of the two rations is given in the following:

	Milk produced. lbs.	Cost per hundred. cts.	Total cost.	Value at $1 per hundred.	Difference between cost and selling price.
Cottonseed meal ration...	2,719.3	54.1	$14 61	$27 19	$12 58
Bran and grains ration...	2,866.0	66.0	18 92	28 66	9 74

While 146.7 pounds more milk was produced from the bran and grain ration, the tabulation shows that the increase was not enough to offset the greater cost of production, hence the cottonseed meal ration proved the more profitable. The gain from the cottonseed meal and the bran and grain ration over the cost of foods when milk is worth $1 per hundred is shown to be $12.58 and $9.74, respectively—a difference of $2.84, which represents the financial gain from feeding the cottonseed meal ration to two cows for sixty days, rather than the bran and grains ration. Applying these results to a herd of thirty cows, the gain from feeding the cottonseed meal ration over the bran and grain ration would amount to $42.60.

The Rational Use of Cottonseed Meal.

The amount of cottonseed meal used in the rations just considered was somewhat greater than that usually recommended. The belief, however, based upon the results of the experiment, is that this amount of cottonsed meal (4.5 pounds daily per cow) can be employed with profit when it is thoroughly mixed with corn silage, or similar starchy foods, as in the case under consideration and when animals are giving a good flow of milk. The injurious effects which have sometimes been reported from the use of this highly concentrated food have, in many cases, at least, been due to feeding it by itself or without being intermixed with any other food stuff. When it is thoroughly incorporated with other foods,

especially those of a starchy nature, it can safely be used in the quantity indicated without injurious effects.

The weights of the cows remained practically the same throughout the experiment. The average weight per cow was 932 pounds for the cottonseed ration and 930 pounds for the bran and grains ration.

The Chemical Composition of the Fodders and Feeds.

In order to properly balance the rations, samples of each fodder were taken for analysis previous to the experiments and the results are shown in the following table. The composition of high-grade fine feeds of the nature of those used in the experiments does not vary materially, hence no analyses were made of them at the time of experiments, the calculations being based upon the average of the analyses made at the Station in previous years. The fertilizer constituents are also added for the purpose of comparing the value of the different rations in this respect.

TABLE IX.

Composition of the Fodders Used in the Experiments.

Station number.		POUNDS PER HUNDRED OF—								
		Water.	Ether extract.	Fiber.	Protein.	Ash.	Nitrogen—free extract.	Nitrogen.	Phosphoric acid.	Potash.
	Corn silage	74.96	1.30	4.94	1.92	1.03	15.85	0.82	0.28	0.95
1618	Cow pea hay	7.32	2.59	28.24	13.96	11.36	36.53	2.23	0.88	3.96
1619	Alfalfa hay	6.83	2.92	21.10	18.51	8.96	41.68	2.96	0.63	2.46
1620	Soy bean silage	74.91	1.47	6.11	4.46	4.06	8.99	0.7	0.16	0.75
	Cornstalks	14.70	1.20	27.30	5.10	5.50	46.20	0.8.	0.28	0.95

Average Composition of Feeds.

Corn meal	12.90	4.00	1.80	9.10	1.50	70.70	1.47	0.62	0.38
Dried brewers' grains	8.90	7.00	13.20	23.90	3.70	43.30	3.82	1.01	0.09
Wheat bran	11.30	4.10	7.90	15.70	6.00	55.00	2.51	2.92	1.57
Cottonseed meal	7.60	10.30	5.20	44.80	6.50	25.60	7.17	3.15	1.79

Fertilizer Value of the Rations in All the Experiments.

The fertilizing value of the rations will be of interest as indicating to a certain extent what food one could afford to purchase when their utility for milk and butter production are practically the same.

In the following table is presented the fertilizing value, that is, the nitrogen, phosphoric acid and potash contained in the rations:

TABLE X.

Fertilizing Value of the Rations.

RATIONS.		Nitrogen.	Phosphoric Acid.	Potash.	Manurial Value.
		lbs.	lbs.	lbs.	cts.
Exp't I....	Cow pea hay ration..........	.674	.250	1.002	13.05
	Feed ration..........	.695	.323	.491	11.25
Exp't II...	Soy bean silage and alfalfa hay ration.....	.581	.145	.490	9.44
	Feed ration	.741	.338	.501	12 11
Exp't III.	Cottonseed meal ration	.667	.259	.479	18.30
	Bran and dried grains ration..........	.661	.314	.482	11.00

The manurial value is estimated on the basis of 80 per cent. of the fertilizing elements supplied in the rations, these being calculated at the rate of 15 cents per pound for nitrogen, 4.5 cents for phosphoric acid and 5 cents for potash. It will be noticed in the above table that the manurial value of the six rations varies from 9.44 to 13.05 cents, a difference well worth considering when calculating the value of rations. It should be understood that when the manure is handled carelessly, dairymen will not get this return in plant-food, but under the best of conditions of care and attention, practically all of these elements could be utilized.

Summary of Results.

1. It is profitable for the dairyman to produce such crops as cow pea hay, alfalfa hay and soy bean silage, and to utilize them in rations rather than to depend entirely upon purchased feeds to supply the element protein.

2 (*a*). A home-grown ration composed of seventeen pounds of cow pea hay and thirty-six pounds of corn silage, producing milk for 20.7 cents less per hundred, and butter for 3.78 cents less per pound than a ration in which two-thirds of the protein was supplied in the form of purchased feeds.

(*b*). When milk is selling for $1 per hundred pounds, the grain from feeding the home-grown ration to thirty cows one month would amount to $37.20 more than the feed ration.

(*c*). Cow pea hay was worth $11.75 per ton when fine feeds were used in the proportion, and selling at the prices quoted in the experiment.

3. A ration (which can readily be grown on most farms) composed of 36 pounds of soy bean silage, 8 pounds of alfalfa hay and 6 pounds of corn meal, produced more milk and at a cost of 8.5 cents less per hundred than a ration in which the protein was largely supplied by wheat bran, dried grains and cottonseed meal.

4 (*a*). A ration supplying protein in the form of cottonseed meal produced milk for 11.9 cents less per hundred and butter for 3.3 cents per pound less than when protein was supplied in the form of wheat bran and dried grains.

(*b*). On the basis of the results obtained, the grain from feeding cottonseed meal in the place of bran and grains would amount to $42.60 for thirty cows sixty days.

(*c*). Cottonseed meal is worth $42 per ton, when bran and grain can be purchased for $21 and $20, respectively.

5. The fertility value of foods is an important consideration in compounding rations.

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REPORT OF THE BIOLOGIST.

EXPERIMENTAL STUDIES IN OYSTER PROPAGATION 1903.

THE ARTIFICIAL PRODUCTION OF OYSTER FRY.

§ 1. Introductory.

From the Biological Department there was issued early in the summer, bulletin No. 166, dealing with the subject of "the proper disposal of sewerage wastes in rural districts," so as to prevent the spread of, and infection by, intestinal parasites, such as tapeworms, typhoid germs, etc. Directions were given for the proper maintenance of the dry-earth closet, which method of disposal was considered the best, in the absence of a good sewer, and a most efficient means of preventing the contamination of drinking water through undesirable drainage, and of food through the transference of disease germs by flies.

The Biologist has during the past year confined himself principally to the prosecution of experimental studies in oyster propagation, to which subject this report will be restricted. This is the third report of progress in securing results in pursuance of the provisions of special act of the State Legislature providing for these experiments. See Laws of New Jersey, 1901, chapter 99. The annual appropriation for this purpose was increased to $300 for 1903-4. This increase was quite necessary, as our researches have reached a stage demanding more extensive operations than at the early stages of the investigations.

The plan of these studies has been the thorough study of oyster development, beginning with the fertilization of the egg, and the focusing of attention upon a limited portion of this development in successive stages. Accordingly during the past season the

work was confined to the problem of producing oyster fry suitable for spat fixation, leaving the questions involved in the processes of "spatting" for future investigation.

The studies of previous years had laid a good foundation in our knowledge of the effect of various conditions on the successive stages of fry development. This experience was applied in over forty experiments during the last spawning season, each lasting from two to five days. It is relatively easy to start a great quantity of apparently healthy fry, but in scarcely more than one per cent. of the experiments conducted without regard to these recently discovered principles, does the fry continue to develop normally and to attain the stage when they possess a bivalved shell and are seeking a place of fixation upon some object called a "collector" or cultch.

The season's experiments can be divided into the following classes:

(*a*). Those in which the conditions were clearly known to be unfavorable, and so the poor result was foreseen.

(*b*). Those in which the conditions were apparently favorable, but in which a new condition was brought to bear for experimental purposes which destroyed the fry.

(*c*). Those in which the known conditions were apparently favorable, but for some inexplicable reason the result was poor.

(*d*). Those in which the known conditions were apparently good and led to a successful issue.

In computing the ratio of successes, it is plain that only cases (*c*) and (*d*) should be considered. To the former belong only three or four cases, while in twelve experiments the fry reached the shell stage in a most satisfactory manner. This makes eighty per cent. of successes, whereas, in the preceding season, which gave the best previous record, we obtained such fully-developed fry only three times, and that by chance, and so were ignorant of the conditions upon which such results depend. In the light of the experience secured by a study of the successful experiments and a comparison with those giving poor results, we are able to prepare at will an abundance of fry suitable for the next step in our experiments, viz., the fixation of the spat.

OBSTACLES.

These encouraging results were secured in the face of unusual obstacles. In the first place, the fire in the State Laboratory at New Brunswick damaged the equipment of apparatus used by the Biologist and otherwise caused so much delay that the work was begun a full month later than was the original intention. In the next place the summer was unusually cold, many batches of eggs being fatally retarded in their development. Several of the experiments were seriously interfered with by destructive storms and tides of unusual magnitude.

Such untoward conditions, introduced by nature haphazard into investigations in which the ability to interpret results depends entirely on the fact that the experimenter has complete control of all the factors of influence, led the Biologist to desire an improved equipment. For example, he believed that an incubator would be a great help, perhaps even a necessity. An incubator was finally secured and tried in the later experiments; but its introduction brought new conditions, unfavorable as well as favorable, that will require adjustment and future experimentation.

A host of contingencies not present under natural conditions, arise under artificial manipulation, and these must be properly adjusted so that the delicate fry shall not suffer. At every new test there arise many new suggestions that call for trial, each involved in difficulties that must be overcome. The study of oyster breeding is not as simple as the study of the breeding of the higher animals and plants. At each experiment the adult oysters have to be opened and their lives sacrificed; also, the young are so very minute, being on the very verge of our vision. As the spawning season is confined to a few weeks, it follows that the great labor of establishing a scientific system of artificial oyster propagation will necessarily be a protracted one.

A FLOATING LABORATORY NEEDED.

Most important of our needs is a laboratory built with special reference to this work in the light of our experience. Such a laboratory should be established in conformity with the aim of the law, but will require a special appropriation, as the small annual appropriation is sufficient simply for incidental expenses.

Such a laboratory should be a boat capable, therefore, of floating above the "storm-tides," flat-bottomed so as to sail in shallow water, large enough to accommodate apparatus for securing oysters as well as that of investigation, and also the tanks for holding the fry and oysters used in the experiments. It should also provide dormitory, kitchen and dining facilities—in fact, it should be a house-boat.

Such a laboratory can be stationed at various points on the coast in the oyster-bearing areas; it can be anchored on any oyster-bed which it may be desired to study carefully. By virtue of its movability, it would give the advantages of a well-equipped station to every locality where it might anchor, and in any event, the investigator can use only one station at a time; besides it is disadvantageous to his experiments to move from one station to another. Our success is in good measure due to the fact that we confined our work almost uninterruptedly during the past summer to the Mott Station. This station offers certain exceptional facilities, in spite of its being difficult of access, in that here we have been able to secure oysters in full spawn all summer long.

Accessory to the house-boat should be a motor launch, of, say, three horse-power, to tow the house-boat whenever it requires to be stationed in a new location. It would be unwise to equip the large boat with its own engine, etc., as it could not be readily used for making temporary and rapid excursions to distant points to secure materials and supplies.

Such an equipment will cost but little more than a single station on shore adequately furnished, and could likewise cost but little more annually in maintenance, certainly less than would several shore stations.

§ 2. Questions Still to be Answered.

VENTILATION AND FOOD.

The prime essentials of all animal life are oxygen and food. The latter is stored in the egg so that a developing oyster embryo does not require food until it has attained the shell stage; but the former must be supplied in suitable amount constantly, from fertilization onward, if there is to be any development at all. Marine organisms receive their supply of oxygen by absorption of the air, which is taken up by solution in the water in which they live. In turn, this water absorbs the carbonic acid gas and other excretions of the living organisms it contains. In nature the water becomes purified by exposure at its surface and by containing minute green plant organisms scattered through it. The latter do not purify water except when illuminated by sunlight.

In our experiments we start great numbers of fry in a small quantity of water. So long as the embryos settle to the bottom of the dishes the stale water can be readily poured off and fresh seawater added, but after the embryos become swimming fry this is no longer practicable. Other experimenters have usually solved this problem by adding new water to that already on hand and so progressively diluting the preparations and increasing the bulk of the water. This is disadvantageous in two ways—first, the fry are so diluted that it is difficult to secure them for examination, and secondly, the accommodations for the fry must be so ample as to greatly tax the room and other facilities such as incubators for holding the preparations. It is much simpler to deal with small quantities of water well crowded with fry, and we have perfectly succeeded in raising magnificent fry under such conditions.

It occurred to us that if the fry could be raised in a small enclosure, which would retain them though allowing free passage of water, the embroyos held in such receptacles, immersed in the creek or in the claire, would experience conditions similar to those surrounding the embryos produced naturally in such water.

An examination of the creek water at certain dates proved that this is filled with swimming fry in the shell stage, and while no abundant set of spat is produced, still the creek banks contain

here and there a natural oyster. But the vast majority of the very numerous shells planted on the bottom of these creeks remain free from spat. The reason for this has yet to be discovered.

At any rate, we felt that there was a promising field for experimentation along this line, because under such conditions the fry could also secure their proper food, which consists of the smallest organic particles in the water, and in that case might even be induced to "set" upon special collectors introduced into such receptacles. The problem of feeding the fry artificially is one that still remains for solution. It seems impracticable to introduce food into their artificial confines, as in this way the water becomes foul and thus causes the death of the fry. The question of the kind of food suitable and how to secure it is also still unanswered.

A very considerable part of our efforts was directed towards the use of such receptacles, which we may divide into two classes, viz., "pockets" and "dialysers."

"Pockets" were made from various cloth fabrics and from filter-paper hung in floating frames. These allow the water to flow freely in and out. The "dialysers" were impervious to water, though allowing the passage of gases. In the latter, the water once introduced remained unchanged, but its air contents remained approximately similar to that of the water of the creek, which bathed the dialysers on the outside. These receptacles were made from starched filter-paper, parchment and sieves, whose bottoms of hair or of cloth had been collodionized to stop up their pores. The dialysers were not tried until late in the season and have not been fairly tested. The pockets proved utterly disappointing. Even those made from bolting cloth allowed these very small embryos to escape, and moreover, a layer of sediment accumulated both within and without, consisting not only of food organisms, but of microscopic enemies and of dirt. It was plain that any fabric that would allow the entrance of food would also allow the entrance of undesirable particles and, moreover, would permit the fry to escape.

The question then of feeding the young must be settled in a different way.

In this connection it is necessary to consider another matter, which we learned by experience. The mud, so deep and black, which constitutes the creek bottoms, and indeed the very marsh

itself to a depth of ten or more feet, consists on its surface of a layer of rapidly multiplying organisms on which the oysters feed, and on the abundance of which the rapid growth of the bivalves depends. Lower down, this mud consists of decaying organisms that undergo a constant fermentation, giving off sulphurous gases that are no doubt absorbed by the water.

We found that if we used water for our experiments taken at low tide, there was abortive development, whereas if the water that rolled in on the last of the flood was used the results were far better—indeed, if other factors were right, we secured a successful outcome by such a choice of water. We also found in comparing those fry kept in dialysers with those kept in tumblers that the latter generally developed better than the former, though the ventilation favored the former. This could be explained only by supposing that the dialysis at low water was injurious.

This shows that so far as claires in such marshes are concerned, they must be constructed with sandy bottoms, and must be so made that they receive water only on the highest flood. Into such claires the fry must be put when they are ready to feed; and in such claires they should "set" upon collectors.

But here a difficulty is encountered. The gate of such a claire must be made to readily allow the inflow and outflow of water and at the same time retain the fry. In our experience, any gate tight enough to prevent the passage of fry became so clogged with mud as to prevent the passage of water. It is true that Dr. Ryder, in a similar experiment, had good success using sand for a filter, but he had much less flow of tide to deal with. Yet it must be quite a feasible matter to solve this difficulty, only it requires considerable experimenting. Ideas do not work out when tried in the way they were expected to do when they originated as suggestions.

This matter of food has been here considered by us at length for the double purpose of showing what yet remains to be done before a system of artificial spat production can be even inaugurated, and of indicating the nature of the difficulties that arise to retard progress.

§ 3. Problems Solved.

We shall now proceed to briefly discuss those questions which our experiments have answered to a satisfactory degree. They pertain to the oysters used, the spawn used, the water used, manipulation and temperature.

THE SEED USED.

Northern and "native" oysters planted in our waters come into spawning condition in June, and usually have completed spawning early in July, whereas oysters secured from southern sources and planted in our waters may be found in spawn at any time from June to September. This is particularly true in regard to the oysters planted in Mr. Mott's pond. But it is a general characteristic of southern oysters, on their home grounds, that they are in spawn for a long time; sometimes spawn can be found in them throughout the year.

Sperms suitable for fertilizing the eggs must be in rapid motion as viewed under a microscope, and the eggs should be somewhat irregular in shape, approaching the pear-shape in southern "plants." They should be neither very transparent nor be very opake, having coarse, intragranular material. The nucleus should be central in position, and there should not be much extragranular material mixed with the eggs as they issue from the reproductive gland. These qualities are present only when the oysters are just ready to eject their spawn. This spawn is not all thrown out at once; frequently a considerable amount is retained, which undergoes dissolution and is transferred to other parts of the body, where it is transformed into fat, the fat being again utilized for spawn formation the following season.

Sometimes there is no spawning at all, the entire contents of the reproductive gland being gradually and slowly broken up. In that case, to judge of the character of the spawn, it is necessary to make a microscopical examination. Otherwise, a partly spawned-out oyster is readily discerned by ordinary inspection. Eggs from the latter will indeed develop, but they fail to reach the shell stage.

THE WATER USED.

The water used must be of the best. Only that entering the creek on the highest part of the tide (the higher the better) is adapted for use in such experiments. It is also necessary to filter such water, that parasitic organisms and microscopic enemies may be excluded. Otherwise these are sure to multiply in the dishes during the progress of the experiment, and so to destroy the embryos.

MANIPULATION.

Utmost speed in manipulation is necessary, as the eggs are very sensitive and begin to deteriorate at once after the oyster is removed from the water. Yes, even transplanting from one locality to another not far away, and where, it might be presumed, the conditions were identical with those in the old locality, produces a marked change in the eggs.

A very small quantity of the male fluid is taken on the point of a knife and stirred into a tumbler of suitable sea water, then the eggs are similarly taken and added with stirring. The water is kept in motion to prevent the eggs from settling, for about ten minutes until their impregnation is completed. The contents of the tumbler are then poured into a broader dish and the eggs allowed to settle. Then the turbid water is drawn off and a new supply poured on the eggs. This process is repeated until the water comes away clear and the washing of the eggs is completed. They are then left (with occasional stirring) until free swimming fry appear, which are then siphoned off, and the residue (consisting of undeveloped or half-developed eggs) is discarded.

From time to time it may be wise to remove any *debris* that settles.

TEMPERATURE.

All the best results were secured when the temperature did not fall below 70° F. nor exceed 80°. A very few degrees seemed to cause a surprising difference. The natural tem-

perature of the creek water gradually rose from the lower to the upper of these extremes during the season. But the temperature of the air varied greatly, so that during the night, or early in the morning, it often fell below 60°, while after noon, soaring into the nineties. Thus it becomes necessary to float the dishes upon the creek, or still better, to use an incubator whenever the temperature falls below 70°, and to float the pans in the claire whenever the air temperature exceeds 85°. At the lower extreme it takes thirty hours or longer for the embryos to attain the shell stage, while at the upper limit this stage is reached in twenty hours or less.

VENTILATION.

Fresh air is a prime requisite as well as a fresh (not stale) condition of the sea-water. The fumes of kerosene, naphtha, tobacco, etc., are highly injurious, as well as the gases from fermenting mud. Indeed, the problem of ventilation in connection with the use of an incubator and the running of the experiments over night requires the installation of some form of motor to supply air and agitation.

SUMMARY.

We may summarize the factors or conditions on which success seems to depend, as determined up to the present, thus: Oysters freshly tonged, filled with spawn, consisting of ripe, clean eggs, speedily taken and fertilized, without crowding, by a small quantity of motile sperms, in well-filtered, fresh sea-water taken at full flood-tide, thorough washing of the eggs, occasional agitation and good ventilation, while keeping them at a temperature as near 75° as possible, with care to prevent their exposure to temperatures below 60° or above 80°. A failure in one or more of these respects proves fatal. Under the above conditions, if the fry do not reach the shell stage on the third day, counting the day of fertilization as first, it is evidence that an unknown factor fordooming to failure has influenced the experiment.

Journal of the Experiments.

Experiment 1. June 2d, 11:45 A. M., opened freshly-tonged East River seed planted two and one-half years ago in Stopwater creek, near the laboratory. Six were ripe males that had begun spawning, and there was an equal number of females whose eggs may be described as follows:

(1) Greenish; eggs, angular, imbedded in granules.
(2) Very full of spawn, eggs elongated, few granules.
(3) Eggs round, somewhat granular within.
(4) Eggs round, somewhat granular within.
(5) Eggs round, somewhat granular within.
(6) Full of spawn, eggs fair.

Fertilized (*a*) eggs from each female by mixed sperms of all males and (*b*) mixed eggs of all females by sperms of each male, and (*c*) "all by all" finished at 12:30, and completed cleaning by 1 P.M. At 2 P. M. the polar globules begin forming and segmentation into three spherules at 2:45. Warmest to-day was 71° F. The males seemed about equally good, but the females 2 and 6 showed the largest proportion of developed eggs, determined at 6 P. M. All lots were united in one pan, and floated in a floating box in the claire, because air temperature had fallen to 64 degrees, while water temperature was 69° F.

June 3d, at noon added a little rain-water to counterbalance evaporation. This seemed to destroy the embryos.

Eperiment 2. June 2d, at 5:30 P. M., separate fertilized eggs of two native females from Elder creek, by mixed sperms of eight males well filled with spawn. Female (1) had elongated eggs with few external granules, while those of female (2) were irregular, and there were many granules, both internal and external. Spawn was so abundant in (1) that the eggs taken were crowded. Floated in tumblers in box in claire.

June 3d, at noon found most and best fry in (2). One tumbler left on the table runs up to 77°. Fry descends in columns near the glass surface. Tied bolting cloth and handkerchiefs over the mouths of tumblers in the box in the claire and submerged them in upright, horizontal and reversed positions. Found that the fry escape through the meshes of all samples, so made four thicknesses of each sort of cloth. Day warmer, maximum 81°.

June 4th, at 5 A. M., fry submerged in water at 64° not active; those in tumbler on table seem to be doing nicely, though temperature had run down to 56°. Left on business and returned Friday evening.

June 6th, Saturday at 9 A. M., found that cloth affords a breeding-place for pigmented bacteria and algæ; fry now all decomposed or gone.

Experiment 3. June 3d, Wednesday, 6:30 P. M., opened (*A*) four females, Hog Island seed from pond, one fairly good, others poor; one with many granules external to egg; also two males; (*B*) two males and two females, natives from pond. Of latter, one is fairly good and one has somewhat opake eggs. At 7:15 P. M., made six lots by means of mixed fertilization and reciprocal crossings of *A* and *B*. At 9 P. M. the development showed native spawn was poorer than the Hog island spawn; the native eggs crossed with the Hog island sperm were better than when fertilized by native sperm; and the Hog island eggs fertilized by Hog island sperms were best of all. Tumblers were left on table; night was cold.

June 4th, Thursday, at 5 A. M., found that development was arrested before attainment of swimming stage. Poor eggs, delayed fertilization after opening, improper handling, imperfect cleaning and low temperature combined to produce this unusually poor result. Probably, also, the water used was not of proper quality.

Experiment 4. June 6th, at noon, fertilized mixed eggs of two females. Hog Island plants from pond transferred to creek bank, Wednesday last. Fair development noticed at 2 P. M.

June 7th, morning examination showed that the fry were few and feeble, but decanted off enough to make one tumbler of fair fry.

June 8th, embryos are well, but slow in development, owing to prevailing cold weather.

June 9th, Tuesday morning, shell stage reached. The top swimmers were mixed with top of No. 6 and planted in a pocket made of startched filter-paper, backed by sheeting and floated in claire.

June 10th. These embryos had decomposed, due in part to fermentation of the starch.

Experiment 5. June 6th, at noon, fertilized eggs of four East River plants from creek, by sperms from four males. Poor development resulted.

June 7th. Morning examination showed that the fry were few and feeble.

June 8th. Still alive, but cold weather makes their development slow.

June 9th. Not yet in shell stage, thus unlike No. 4.

June 10th. Not yet in shell stage. Next examination was June 20th, when the *debris* in bottom of tumbler showed that a few had reached shell stage.

Experiment 6. June 6th, at noon, fertilized eggs of four native females from pond, transferred to creek last Wednesday. Only in the first female was a jelly-worm present. Sperms of one native male, six Hog Island males and four East River males used. At 2 P. M. the development was slow, probably owing to low temperature.

June 7th. Morning examination showed a fine lot of fry, most of which were planted in cloth pockets hung in a slab, floating in the claire. The material of these pockets was, respectively, as follows: (*A*) cotton flannel; (*B*) wool flannel; (*C*) bolting cloth; (*D*) India linen; (*E*) "best" sheeting. At 6 P. M. the embryos had disappeared from all these pockets and were replaced by numerous infusors, showing that the meshes of all materials were too coarse to retain and to protect the fry. Restocked pockets (*D*) and (*E*). Observed that when the embryos are few in a tumbler they form surface "clouds" rather than "columns."

June 8th, Monday morning. Rain during night had greatly diluted the water in the floating tub, and the contained fry were feeble. In pockets (*D*) and (*E*) there are a few fry left. Those in the tumbler in the laboratory are inactive, due to cold.

June 9th. Shell stage reached. Temperature rapidly rising. Mixed some with No. 4 and planted them in a pocket made of starched filter-paper. Observed that as temperature rose, the fry formed columns in centre of tumbler.

June 10th, Wednesday morning, fry had decomposed, due, in part, to bacterial invasion of the starch.

Experiment 7. June 8th, Monday, 11 A. M. East River plants

from Stopwater creek, four of each sex. Planted almost all, as soon as fertilized, in the five pockets; also, put one lot in tumbler on laboratory table. Temperature at 2 P. M., 75°. Rotation begins at 5 P. M. and columns formed at 5:30. In the pockets, no motion until 6 P. M. The temperature, like that of tumbler, is 70°. Query: Do the most active and forward ones escape from the pockets, or is the difference in rate of development due to the difference of 5° warmth at 2 P. M.?

June 9th, Tuesday, 3 P. M., found tumbler filled with the finest shelled fry I ever saw. Planted half of them in a special pocket float, made of starched sheeting. Also, replaced pockets *A, B* and *C* by starched paper pockets. Stocked all pockets with shell fry at 4 P. M. Temperature 76° F. At 6:45 these fry had disappeared from pockets *A, B* and *C,* and, in part also from the other pockets.

June 10th, Wednesday morning. Fry in tumbler same as last night, but none left in any pocket.

Experiment 8. June 9th, 11 A. M.—Temperature, 78°. Natives from pond transferred to creek. Only two of the females used. Eggs fertilized by sperm of two ripe males.

(*a*) Female, with clear "hood," extra fine collection of spawn; some eggs, however, had swollen spaces between shell and yolk.

(*b*) Female, still contains fat in the "hood;" eggs elongated, with large, clear, eccentric nuclei, and fine granules oustide the eggs. Eggs pressed out with difficulty. Consider this not quite mature.

At 2:15 P. M. about 12 per cent. were well segmented in *b*. Before 6 P. M. rising columns in *a*. At 6:45 not yet columns in *b*.

Most of these were combined with No. 9 and planted in all the pockets.

June 10, Wednesday morning.—*b* is poor and *a* is better, but no shells yet. Nothing left in the pockets. Next examination was on June 20th. Nothing but decomposition *debris* found in all lots, except *a,* in which were many empty shells.

Experiment 9. June 9th, noon.—Two good females and three fair males, selected from thirteen Hog Island plants from pond, transferred to the creek. The poor eggs were decomposing, opake and granular; and the nuclei were escaping from the egg membranes.

Observed that it takes eight minutes for the eggs to settle one inch; also, that, after the jelly-worm is removed, it takes three-quarters of

an hour to dissolve. Temperature, 78° at 2 P. M., when segmentation had begun.

Separated the light eggs as 9*b*. At 6:45 P. M. 9*a* forms columns, and most were planted with No. 8 in the pockets.

June 10th, Wednesday morning.—All disappeared from pockets. Examined tumblers June 20th, but no shells found in the *debris*.

Experiment 10. June 20th, at 1:40 P. M.—Temperature, 68° F. East River plants from Stopwater creek. Used five good females, some external granules, equals *a*, and four second best females, egg nuclei enlarged and escaping, equals *b*. Mixed sperms of six males. One oyster had gregarinoid parasites, that undergo slow vermicular contractions and stretchings. Extra high tide covering marsh. Specific gravity of this water was 1,014 (raining). Used filtered water and wooden bowls (paraffined) for this experiment. Temperature of air, 68°, about same as of the water. At 3:45 the polar cells formed in both lots.

June 21st, Sunday morning.—Top-swimming fry in *a*, but only few feeble bottom ones in *b*. At noon air was 78° F. Specific gravity of water in claire at 70° equals 1,016. Separated top of *a* from the bottom.

June 22d.—Morning quite cold. Water in bowl was 56° F. At 10:30 not yet 70°, so planted most of *a* in a special pocket, made from Schleicher and Schüll filter paper, backed by "India linen." Those left in the tumbler form columns.

June 23d, Tuesday.—Cold, northeast storm and extraordinary tide. No shell yet in lot in tumbler. Shell gland present in the lot floated in claire. Had quite a time to keep apparatus from floating away and from being filled by rain-water. At last the billows that rolled in over the marsh upset all the lots floating in the claire. The lots left in the bowls in laboratory showed only *debris* at noon, June 24th. Still cold.

Experiment 11. June 22d, Monday, at 3:45 P. M.—East River plants from Stopwater creek. All had partly spawned out. Selected three females that had just begun spawning, equals *a*, and two that were nearly through, equals *b*. Used eight males. Weather cold. Floated part of No. 11 in a pan in claire, and some in pocket *A*, and rest was put in a tumbler in the laboratory.

June 23d, Tuesday.—Cold, northeast storm. 11*a* not swimming at 6 A. M. No motion at all in 11*b*; but in floating pan, because water was warmer than the air, the development is most advanced.

So put the tumbler of 11*a* also into the pan, which was later upset by billows from a storm tide, which rose about two feet above the laboratory floor. 11*b* failed to develop further.

Experiment 12. June 24th, Wednesday noon.—Selected six best females out of eleven, and five males; East River plants from Stopwater creek. After fertilizing, put some (before cleaning) in pocket *E* in claire, because weather was so cool. Also floated some in a pan (after cleaning), and balance was put into a bowl.

June 25th.—Was so disgusted at high tides, I planned a floating laboratory. At 4 P. M. the floating pan showed only a few top embryos and many feeble bottom ones. Separated the bottom residue and put it into pocket *D*. Eggs in *E* were not so good as those left in bowl in the laboratory.

June 26th, Friday morning.—Still cool weather—only 70° by noon.

Pocket *D* has only few feeble embryos; but fry was "fair" in the floating pan, whose temperature was 67°. Still normal, but not yet shell at 6 P. M.

June 27th, Saturday.—Last night was cold. Not yet shell stage in any lot. Left until July 7th, when there were found no traces of oyster embryos, but only large number of infusoria and diatoms.

Experiment 13. July 7th, at 10:45.—Temperature of air 88°, and of claire at low tide 77°. Water in laboratory 81° F. Used sixteen East River plants from the creek, most of which had completed spawning. One male was "fair," four had only a little sperm. Three females were fair, equals *a*, and three were half emptied, equals *b*.

At noon some of the eggs had reached eight segments. At 1 o'clock the temperature was 92°. Embryos were forming columns at 3 o'clock.

Prepared a tumbler of "top" eggs; also put some of *a* into a wooden bowl, some into a tumbler and some into a small sieve floated in the claire, low water. The sieve bottom was made of collodionized India "linen." Later transferred contents to large sieve, because the cedar wood of small sieve colored the water brown.

At 6 P. M. the sieve embryos were dead. Stocked sieve made of collodionized horeshair with swimming fry from tumbler.

July 9th, Thursday morning.—Examination shows that 13*a* top eggs contained a few feeble bottom embryos and many infusors. It must be explained that these eggs were the light ones, which settle slowly and were drawn off after the bulk of the fertilized eggs had

settled, after the final clearing or washing that completes the removal of the sperms.

13*a* bowl and tumbler embryos were in good condition.

13*b* was not so good. Temperature was 94° at 2 P. M., and 86° at 7 P. M., when none of the fry had reached the shell stage. I put part of 13*a* into the big sieve and floated in claire. It must be conceded that these preparations had been exposed to extraordinary warmth.

July 10th, Friday morning.—Cool just before sunrise; 13 fry not yet in shell stage, but infested with infusors. Samples in the sieves doing poorly, most dying, presumably due in part to effect of ether in the collodion film; but also the excessive temperature, the infusoria and poor quality of water influenced the result. Temperature again rose to 94°; the water, 88°. Still failed to reach shell stage at close of this day.

July 11th.—Again a hot day. All lots of No. 13 apparently "played out." Collected the best survivors and put them into hair sieve. Did not avail.

Experiment 14. July 10th, 5 P. M.—In the pond, selected two natives of each sex. Most of natives were through spawning. Floated the eggs in a claire. Eggs were much crowded.

July 11th, Saturday morning.—Many swarming embryos. Weather warm; rose to 90° by 9:30. Distributed the fry as follows:

(*a*) Covered wooden bowl on laboratory floor.

(*b*) Tumbler in float in claire.

(*c*) Tumbler on table in laboratory.

Cleaned all at 6 P. M., and put top of *debris* into hair sieve.

July 12th, Sunday.—Cooler. All fry slow; best in sieve. Heavy storm and cloudburst at 3 o'clock upset the hair sieve.

July 13th, Monday.—Still raining. Found all the outdoor (floated) lots had been diluted by rain-water, and few fry remained. But the preparations in the laboratory were also poor and sickly—practically gone.

Experiment 15. Friday, July 10th, at 5:15 P. M.—In the pond: Used one well-filled Hog Island "spawner" of each sex. Temperature, 90°.

July 11th, Saturday morning.—Weather still "hot." A large number of fry developed. Put some into bowl on the floor and some into a pan floated in the box in the claire.

July 12th, Sunday.—Embryos are sickly. In afternoon had a

heavy rain—two inches falling in thirty minutes. Hair sieve upset again.

July 13th, Monday.—Planted some in the hair sieve. Cooler; did not exceed 80° this day.

At 5 P. M. transferred contents of hair sieve to large sieve, and planted contents of laboratory bowl in the hair sieve.

July 14th, Tuesday.—The embryos practically finished their career this day, giving only poor results.

The lack of successful issue in 14 and 15 must be attributed to a combination of various causes, among which may be mentioned overcrowding, overheating and poor quality of water used.

Experiment 16. July 15th, Wednesday morning, at 9:30 o'clock.—Opened East River plants that had lain on the creek bank so as to be uncovered at half ebb. Found them in good spawning condition, and used two of each sex in the fertilization experiment.

I found a high proportion of light or "top" eggs. Only a few of this lot segmented; possibly the sperms were at fault. The light eggs produce much feebler and slowly-developing fry than the heavy ones. Floated some in tumbler in box-float; water, 70°.

July 16th, Thursday morning.—Cool. Water in bowl appeared stained, so added a mixture of top and bottom fry from tumbler after cleaning, and compared with contents of the tumbler.

July 17th, Friday morning.—Only a few fry still alive and mostly in tumbler. Cleaned the lot again. All disappeared by Saturday morning.

Experiment 17. July 15th, Wednesday, at 3:15 P. M.—In the pond, using specially prepared and selected water, made a fertilization of native eggs from partly spawned out females. The eggs, on cleaning same at the laboratory, proved nearly all to be "light." Lot left in bowl in the laboratory.

July 16th.—The developing fry were too few to form columns, and the unsegmenting eggs too light to separate from the fry.

July 17th, Friday.—Lot looks opalescent from floating *debris;* many infusors developing. By evening, the temperature of the water being 76°, the infusors were sole occupants.

Experiment 18. July 15th, Wednesday, at 3:20 P. M.—In the pond, using specially selected water, I fertilized abundant lot of eggs from a Hog Island female by sperms from two males. Eggs crowded, and not cleaned until about 4 o'clock; completed at 6 P. M., when air was 70°; claire water, 72°, and creek, at low water, 75°.

Divided the lot into several portions: *a,* in large sieve, floated in the creek; *b,* in pan in box-float, in the creek; *c,* in tumbler, floated in claire; *d,* in pan, on the floor of laboratory.

July 16th, Thursday morning.—All lots show very good fry; the laboratory lot is slowest, but all form "columns." By night the lot in the sieve form "clouds," while others still form columns.

July 17th, Friday morning.—Weather warm this day, but not excessively so. All lots in fair condition, but those left in the laboratory were matted together in clusters at the bottom. Tendency to form columns had been lost. All lots were cleaned. By evening the shell rudiments show in *a.*

July 18th, Saturday morning.—*d* fry were sickly, and no further advanced than shell gland stage. The other lots also showed no further advance. This was a fine lot of eggs and started out well. The only causes of poor results must have been the crowding at the start of the experiment, and, in the case of the sieve, also the poor quality of water at low tide.

July 19th.—Only a few left in *a, b* and *d*—all just at the beginning of the shell stage; *c* had received considerable rain-water yesterday. Most was decanted off, and high-tide water added to the *debris.* Early shell stages show this morning.

Experiment 19. July 18th, Saturday, 9:45 A. M.—Hog Island plants from creek at outlet of pond. Three females and two males, in good condition; also used males from East River plants taken from same point, and from Hog Island plants, taken Wednesday from the pond and transplanted to the opposite shore of the pond. In cleaning, ran short of high-tide water and had to use low-tide water. Was careful to keep eggs from smothering.

Eggs were kept in bowls in the laboratory, with care to keep them cool as possible in warm weather; also in tumblers that were placed in claire water at 74° when air runs below 70° and above 88°. First motion at 2:30.

July 19th.—After cleaning, put residue in the big sieve.

July 20th.—Not yet in shell stage. Added rain-water to counteract evaporation. This caused swelling and fry became feeble.

July 21st.—Fry so poor, though they had reached the shell-gland stage, that they were discarded.

As the temperature had been ideal, and the treatment most careful,

the poor results must be laid to the poor water used, and probably also the dilution with rain-water. This had been suggested by the experience with No. 18, in which the lot rained on apparently did best.

Experiment 20. July 18th.—Three fine Hog Island females from the pond shore, with clear hoods. Fertilized like *Experiment 19,* and with similar subsequent history of poor results, though this lot was best all through.

Experiment 21. July 18th.—East River females from outlet of pond. Same history as *Experiments 19* and *20.*

Experiment 22. July 18th.—Hog Island females from outlet of pond. Had begun spawning and had poor eggs. History like *Experiments 19, 20* and *21.*

These four experiments were conducted simultaneously.

Experiment 23. July 18th, 11:45.—Opened fourteen East River oysters from creek bank. All in fine spawning condition. Only three were males. Subsequent history same as *Experiments 19* to *22.*

All fry gone by July 21st.

Experiment 24. July 21st, Tuesday, 2 P. M.—Hog Island plants from pond outlet were pretty nearly spawned out, though full of spawn last Saturday. Had big southeast storm Saturday and extra high tides since. Opened twenty-four oysters and one-third proved to be males.

At 3:15 P. M. segmentation is under way.

At 6:30 separated the turbid top into which the embryos were rising, equals 24*b,* and put the best into a pan floating in a jar of high-tide water at 78°. Residue in a tumbler on table.

July 22d, Wednesday, 2 P. M.—The last lot in the shell stage. Night proved cold after a shower, though did not fall below 70°.

July 23d, Thursday.—Embryos have early form of the shells, but are irregular and tend to decomposition. Thought it might be due to evaporation, so added rain-water slowly to the lots.

Light eggs of this experiment do not develop into fry.

July 24th, Friday.—Infusoria destroying the lot of embryos; also night was cool.

July 25th.—All dead; only empty shells. Result of irrigating with rain-water.

Experiment 25. July 21st, Tuesday, at 2:15 P. M.—Four East River females, from creek bank, opened and eggs infused into high-tide water; and later added the sperms from the supernatant water

of No. 24. The eggs settle slowly; and so I separated the top and mixed with top of 24 and 25*a*. No. 25 did not become fertilized. The segmenting eggs from the top of 24 settle faster than the unfertilized ones in 25.

Experiment 25b. July 21st.—Discovered many swimming, shelled embryos in the high-tide water. These were secured by filtration through Schleicher and Schüll filter paper. The lot becomes infusoriated by July 24th. I had added a little rain-water. The natural fry swim with their backs down. Fed them some sperms, but result is fatal.

The *debris* in jar was also examined, and at first no shelled embryos found, but filtration of supernatant water shows their presence. By July 26th some were found on the bottom feeding and snapping their shell valves. They lie still awhile and then rush around a little while.

Filtration of the creek water also shows the presence of many embryos with shells. Query: Did these come from the supposed natural spawning of last Saturday?

A peculiar ridge, like a thickened ring or like a layer of cement is present on the edge of both valves of some of these fry.

July 27th.—Discovered clusters of native fry set on stick that had been purposely put into the jar. The clusters were near glass slides tied to the stick. Apparently the fry prefer to set in nooks. They were not stuck fast, for a gentle stream of water dislodged them all.

Examination to-day of creek water failed to show presence of oyster fry, but one large, swimming embryo of *Venus mercenaria*—the hard clam—was found.

July 29th.—Still oyster fry in shell are alive in *debris* of jar, but obtained no further "set."

Experiment 26. July 23d, Thursday, 11 A. M.—Fertilized eggs from pond, Hog Island females. Opened ten oysters and found only one good female and two good males; the others had partly spawned. Water in creek at 82°; specific gravity, 1,015. Put part into a bowl in laboratory and part into a tumbler floated in a pocket in claire.

July 24th, Friday morning.—Found lot in bowl had reached the shell stage. Those in tumbler scarcely reached the beginning of the shell stage by July 25th, and were then decomposing; all gone next day, and no sign of shell. Added rain-water to the bowl—result,

infusoriation. Most are dead by the 27th; a few are well advanced towards setting stage.

Experiment 27. July 23d, Thursday, 11 A. M.—Seven poor Hog Island females from Stopwater creek (one gregarinous) and one male, reinforced by sperms from males of No. 26.

These eggs did not develop well, and the fry were gone by July 25th.

Experiment 28. July 24th, 3 P. M.—Temperature, 86°. Hog Island plants from pond, which had been left on the bank of the creek for one day. Same original lot as 26. Some had begun spawning; some were "fattening" without spawning. Eggs only medium good and few. Sperms in good condition. Used four best males and five females.

At 8 P. M. the fry that had risen were decanted off, and tumbler containing residue was filled with sea-water. Lots were left in the laboratory. Temperature near 80°, but by 3:30 A. M. had fallen to 60°.

July 25th, Saturday morning.—Floated tumbler of residue in jar early this morning; temperature of water in jar being 67°. At 9 A. M. the fry were lively and apparently well. Those in one bowl were on the bottom and decomposing; in the other they were on top and lively. Water, 70°. Added some rain-water to the bowl containing bottom embryos, and, by night, transferred them to a pan and floated in box; now transferred to claire, because the creek current had capsized the box-float, thus losing the sieves. Temperature of water in claire, 79°. The bottom embryos in tumbler appear unhealthy, and next morning were found to be decomposed.

July 26th.—Found none yet in shell stage. Added rain-water to counteract evaporation—result, all decomposed by next day.

The untoward conditions of this experiment were, apparently, the poor quality of the eggs, the effect of rain-water, and probably, also, the variations in temperature.

Experiment 29. July 27th, Monday morning, at 8:30.—Used eight Hog Island oysters, of each sex, from Pond point; all in fine condition. One was gregarinous.

At 3 P. M. found embryos swimming; only a small percentage of eggs had developed, and many were abnormal; perhaps due to crowding at time of fertilization. Floated in a covered bowl in claire.

July 28th, Tuesday morning.—Temperature, 60° at 7 o'clock;

claire water, 70°; water in laboratory, 62°. After cleaning, divided No. 29 into three lots:

(*a*) Bowl left to evaporate.

(*b*) Tumbler left to evaporate (half full at start).

(*c*) Tumbler kept full by adding rain-water.

All floated during night.

July 29th.—Found all lots tremendously invaded by infusors. Night had been warm. Discarded next morning.

Experiment 30. July 28th, Tuesday, at 10 A. M.—Seven splendid Hog Island females and two males, freshly gotten from the pond. Temperature ideal. Rotation begins at 5 P. M. Rain-water added to the bowl.

July 29th.—Lots, especially in the bowl, infusoriated, and by next morning no well embryos remain.

The main cause of failure seems to have been overcrowding and lack of care in cleaning.

Experiment 31. July 30th, Thursday morning, at 5:40.—Used three good females, and two males of Hog Island plants from pond, which had lain on the creek bank for some weeks.

Used great care in cleaning and washing and avoided crowding both of sperms and of eggs. Made four tumbler lots, viz., *a, b, c, d,* fertilized successively; *a* and *b* were cleared with jar water; *c* and *d,* with filtered water. Temperature rose to 88° at noon. Tumblers left on laboratory table. Left for New Brunswick, taking a bottle of this lot with me. Next morning found all decomposed. Had been subjected to intense heat in transit.

August 8th, Saturday morning.—Examination of the tumblers left in the laboratory shows large accumulation of shells and infusoria.

The success of this experiment, in contrast with *No. 30* and preceding ones, emphasized the need of great care in the details of fertilization.

Experiment 32. August 8th, at noon.—Used nine fair females—Hog Island oysters from pond—and one male. Fertilized lots as follows:

(*a*) Few sperms; (*b*) two knife points of semen; (*c*) much semen and great quantity of eggs. Kept lots at 80° during the night.

August 9th, at 3 P. M.—First indication of shell seen in *a,* none in *b* or *c,* but all lots are sickly and decomposing. They had been kept in the dormitory over a lamp and doubtless had suffered from bad air.

Experiment 33. August 9th, at 1:20 P. M.—Temperature, 78°. Used Hog Island plants from pond that had been transferred to the creek. One "fair" female, three medium ones, one spawned out. Five good males. Prepared lots thus: *a* kept in laboratory; *b* in claire; *c* in laboratory by day and kept at 80° at night; *d* 80° all the time. Used filtered water. Creek water is 74°; water in the tumbler at 2:30 P. M. is 78°.

At 7 P. M. separated the fry. Night is warm.

August 10th, Monday.—Temperature still ideally medium, ranging between 70° and 80° for the extremes.

Embryos that had been kept artificially heated seem sluggish. No doubt due to bad air.

At 11:30 saw first sign of shell in *c*. The next most advanced lot was *d*, but *c* keeps ahead of *d*. This is because of influence of "bad" air over the lamp.

At 6 P. M. *a* begins to show shell forming, and in *b* the mantle lobes have formed.

This experiment delicately and beautifully illustrates the influence of even a few degrees difference of temperature, as well as the influence of good ventilation. Oyster embryos are extremely sensitive to slight changes in the various conditions, and a very slight departure on any critical point may determine success or failure, as may be seen in the sequel, thus:

August 11th, Tuesday.—Started a new incubator last night, but found the lamp leaked and this filled the laboratory air with kerosene fumes. Examination of *33* shows *a* degenerating and now fallen behind *b*. The worst decomposed lot is *d*, but *c* is also a dying lot. All of them go wrong, and are discarded by 5 P. M.

Experiment 34. August 11th, at 6 P. M.—Pond Hog Island oysters that had lain in the creek, now rather poor and nearly spawned out, three of each sex, as follows:

(*a*) In laboratory all the time.

(*b*) In the claire all the time.

(*c*) In the laboratory by day, incubator at night.

(*d*) In the incubator all the time.

Next day *d* shows poorest. Weather not especially cool, so as to call the incubator into real service.

August 13th, Thursday morning.—So cool, and the incubator so well ventilated that it ran down to 70°. All lots (*a, b, c, d*) discarded.

Best was *a,* but none reached the shell stage. Aside from the effects of bad ventilation, the real cause of failure was undoubtedly the poor character of the spawn.

Experiment 35. August 12th, Wednesday, at 7:15 A. M.—Hog Island oysters from pond left at point on nearest shore last Saturday. Old lot left there had spawned out. Used five good females and two good males. First motion seen at 1 P. M., and the fry were separated at 2 P. M. Temperature, about 80°.

Prepared *a, b, c* and *d* as in the two previous experiments.

August 13th, Thursday morning.—Temperature, 62° at 7 A. M.; incubator at 70°.

Claire fry in good condition, but not yet shell. Incubator fry clustered and sluggish, not yet shell; *a* and *c* rather sluggish, but shell begun. Here comparison of *a* and *b* shows that higher temperature, except in the morning, had advanced the development, but recent cold and bad air rendered the advanced lot sickly. In *c versus d* we see that though both were nearly at the same temperature, the lot with the better ventilation, though in cooler conditions, outstripped the other.

No. 35*d* (incubator all time) was discarded, and *a* was divided so as to make a new *d.*

August 14th, Friday—*b* (claire) decomposing without forming shell; new *d* pretty fair and in shell stage; *c* (laboratory by day) not so good as new *d; a* like *d.*

August 15th, Saturday morning.—Temperature, 60° at 7 o'clock. *a* beginning to decompose, cleaned (shells); *b* all decomposed; *c* irregular, few left (shells); *d* begins to be infusoriated, cleaned (shells).

At 8 P. M. *d* (incubator) same as in morning; *c* (laboratory by day) infusoriated; *a* (laboratory) better than *c;* discarded next day. But a few survive in fair shell stage in *d* (incubator) until August 17th.

Experiment 36. August 13th, at 4:15 P. M.—Transferred four Hog Island oysters from Pond point to the creek, and opened three good females and one male. Fertilized the eggs by the following procedure: Filtered water taken from creek at height of tide was used. Selected those oysters having clearly defined reproductive areas. Used clean tumblers, half filled with the filtered sea-water. Selected sperms that were motile; took a few on the point of a knife

blade and washed them off into one tumbler. Aerated the water with a pipette. Took eggs four times from each female by knife blade point, with great expedition, and saw that the total amount should not more than just cover the bottom of the tumbler when settled. The water was aerated, as with the sperms, and, the coarse particles settling at once, the supernatant liquid containing the eggs was poured off.

This was poured back and forth between two tumblers, to keep the eggs afloat while being fertilized, which takes nearly ten minutes. The eggs were then distributed to four tumblers, placed in an oblique position, and, after five minutes, the water, turbid with sperms, was carefully drawn off with a pipette, the good eggs having settled to the bottom. New water was poured in, filling the tumblers half or a third full, as before, and the cleaning from sperms repeated three or four times.

Finally, only enough water was added to fill the tumblers a quarter full, and they were set aside while the eggs undergo development, though occasional agitation is beneficial.

After the embryos become swimming the supernatant water containing them is drawn off, and the residue either discarded or again diluted, and a second skimming made.

In cleaning the fry subsequently the settlings are separated, in the same way, and discarded. After the shell stage is reached the fry, being heavy, prefer to lie on the bottom, and only occasionally swim up into the water; then there can be no further cleaning.

The four tumblers prepared were:

(*a*) In laboratory all the time, at varying temperature.

(*b*) Floated in the claire all the time, at about 70°.

(*c*) In the laboratory by day; but kept between 70° and 80° in the incubator at night.

(*d*) Kept continuously in the incubator.

August 14th, Friday morning, 7 A. M.—Air, 75°; incubator, 78°. Later air became colder, because of northeast rain—*a* is at 67°; *d* at 75°; the embryos are sluggish.

August 15th, Saturday.—None yet in shell stage. Water turbid, as if not sufficiently cleaned. All discarded, because decomposing without showing shell development.

I cannot explain this poor result, unless failure to perfectly clean the eggs be accounted sufficient cause of the failure. The air conditions were not quite satisfactory.

Experiment 37. August 14th, Friday, at 7:30 P. M.—Three fairly good females and five males, pond, Hog Island.

Prepared *a* (laboratory) and *d* (incubator).

August 15th, Saturday morning—Temperature, 60° at 7 o'clock. Found *d* in swimming stage, but *a* not so. Added warmed water to *d*, and divided equally with *a*. In evening, at 8 o'clock, neither lot was in shell stage; *d* is sickly. No shell in either lot at 11 A. M. next day, but by evening of that day (August 16th) found few in shell stage in *d*.

Monday morning *a* is only at point of getting shell; *d* was so filled with monstrous larvæ it was discarded; and so, also, was *a* next day.

This poor result is also difficult of explanation.

Experiment 38. August 15th, at 4 P. M.—Five pond, Hog Island females and one male. Used filtered sea-water, secured at the head of Great Bay at same time as we loaded a big scow with sand for the claire. At 10 P. M. embryos begin swimming. Decanted the embryos and added fresh sea-water to the segmenting eggs.

August 16th.—No shell by evening, either in incubator or in laboratory lot; but in the incubator lot we see great clusters of fry swimming about, showing weakness. Tuesday the incubator lot has succumbed to infusoriation.

The laboratory lots also sickly, infusoriated and not yet in shell stage; discarded.

Experiment 39. August 16th, at 10:30 A. M.—Two good males, pond, Hog Island, and three good females used. Three oysters were placed on the sandy floor of the claire. Made four lots, as follows:

(*a*) Few sperms, few eggs.

(*b*) Few sperms, many eggs.

(*c*) Many sperms, few eggs.

(*d*) Many sperms, many eggs.

All four to be treated as laboratory by day; incubator by night.

The more numerous the eggs the slower to settle, due in part to additional *debris* of medium weight, and in part to increased friction. Temperature 73° by noon.

In *a* about five-sixths of the eggs develop; in all the others only one-sixth develop. This illustrates the effect of crowding.

At 4 P. M. *a* shows swimmers that form columns by 5 o'clock. At this hour there are swimmers in *c*, though no columns, and beginning of motion in *b* and *d*, though none rise in the water.

August 17th, Monday.—The fry are sluggish, though some are lively in all lots. Cleaned of *debris*. No shell by night. The water used was from the bay, and was filtered through white filter paper. It seemed dirty. The ventilation in the incubator, however, may also have something to do with the poor results.

August 18th, Tuesday.—All lots decomposed and infusoriated without forming shells, so discarded.

Experiment 40. Monday, August 17th, at 9 A. M.—Two males and three females, pond, Hog Island oysters. Lots fertilized as follows:

(*a*) Eggs infused ten minutes before sperms.

(*b*) Eggs and sperms infused simultaneously.

(*c*) Sperms infused ten minutes before eggs.

Rotation of embryos seen at 2 P. M. At 4:30 decanted the fry. Used creek water, filtered through white paper.

Tuesday, August 18th.—Fry lively in *a, b, c.* Cleaned.

At 4:45 all show mantle lobes. Kept at 82° all night.

August 19th, Wednesday.—All lots show abnormalites and arrested development, also invasion of infusoria, probably due to excessive heat.

Experiment 41. Tuesday, August 18th, 8:10 A. M.—Two males and three females, Hog Island, from Pond point, as follows:

(*a*) Sperms thirteen minutes before eggs (*s–e*).

(*b*) Sperms thirteen minutes after eggs (*e–s*).

(*c*) Sperms and eggs simultaneously (*41*).

Water 78° on laboratory table at 11 A. M. All lots seem to segment alike. At 2 P. M. the fry lively. Kept at 82° all night.

August 19th, Wednesday morning 5:15 A. M.—Found forty-one with mantle lobes started; (*e–s*) and (*s–e*) both in good shell stage. In view of the preceding experiments, this is a remarkable result and deserves further study.

Pressing engagements at New Brunswick caused me to close the season at this point, though only about a week, or at most, two, remained of the spawning season, and that only with Hog Island plants, of which I had about exhausted the supply.

TABLE OF OYSTERS USED IN THE EXPERIMENTS.

ABBREVIATIONS: t.—transplanted; C—creek; S.—stopwater; E. R.—East River seed; H. I., Hog Island seed; N.—native; P.—pond; p.—creek at pond outlet.

Experiment.	Lot.	Date.	Opened.	Plants.	Males.	Females.	Eggs.	Remarks.
1	1	June 2....	11:45 A. M.	S. E. R..........	6	6	Various................	Fairly good.
2	2	" 2....	5:00 P. M.	E. C. N..........	8	2	Granular in one..	Abundant spawn.
3	3	" 3....	6:00 P. M.	P. H. I...........	2	4	Fairly good........	Abundant spawn.
3	4	" 3....	" "	P. N...............	2	2	One fairly good...	Partly spawned out.
4	5	" 6....	11:30 A. M.	P. H. I. C. t...	6	2		
5	6	" 6....	" "	S. E. R..........	4	4		
6	7	" 6....	" "	P. N. C. t.......	1	4		
7	8	" 8....	11:00 A. M.	S. E. R..........	4	4		
8	9	" 9....	10:30 A. M.	P. N. C. t.......	2	2	Very fine.............	Three others very granular.
9	10	" 9....	12:00 M.....	P. H. I. C. t...	3	2	Fair.....................	Nine others decomposing.
10	11	" 20....	1:30 P. M.	S. E. R..........	6	5	Good	Four others second class.
11	12	" 22....	3:20 P. M	S. E. R..........	8	3	Fairly good......	Two others nearly spawned out.
12	13	" 24....	11:30 A. M.	S. E. R..........	5	6	Good....................	Four others poor.
13	14	July 8....	10:20 A. M.	S. E. R..........	1	3	Fair.................	Twelve males and females poor.
14	15	" 10....	5:00 P. M.	P. N...............	2	2	"	Most about through spawning.
15	16	" 10....	5:15 P. M.	P. H. I..........	1	1	"	
16	17	" 14....	9:30 A. M.	S. E. R. t.......	2	2	Good....................	
17	18	" 15....	3:00 P. M.	P. N...............	......	......	....	Mostly spawned out.
18	19	" 15....	" "	P. H. I...........	2	1	Good	Abundant spawn.
19	20	" 18 ...	10:00 A. M.	S. H. I...........	?	3	"	Two others poor, Ex. (22).
20	21	" 18....	" "	P. H. I. t.........	2	3	"	Ready to spawn.
21	22	" 18....	" "	S. E. R. p	1	1	Not mature....	
23	23	" 18....	11:30 A. M.	S. E. R. t.......	3	11	Fine......................	
24	24	" 21....	1:00 P. M.	S. H. I. p.	8	16	....	Spawned out, both male and female.
25	25	" 21....	" "	S. E. R. t.......	......	4	....	
26	26	" 23....	10:30 A. M.	P. H. I. t.........	4	3	One good............	Two good males.
27	27	" 23....	NOON.	S. H. I. p.......	1	7	Poor.....................	Taken one hour earlier.
28	28	" 24....	3:00 P. M.	P. H. I. t........	4	5	Fair......................	Partly spawned.
29	29	" 27....	8:00 A. M.	P. H. I. t........	8	8	Fine	
30	30	" 28....	10:00 A. M.	P. H. I...........	2	7	Extra fine...........	
31	31	" 30....	5:30 P. M.	P. H. I. C. t...	3	2	Good	
32	32	Aug. 8....	12:20 P. M.	P. H. I..........	1	9	Fair......................	
33	33	" 9....	10:30 A. M.	P. H. I. C......	5	1	"	One spawned out; three medium.
34	34	" 11....	6:00 P. M.	P. H. I. C......	3	3	Poor	Nearly spawned out.
35	35	" 12....	7:00 A. M.	P. H. I. t.......	2	5	Good	
36	36	" 13....	4:00 P. M.	P. H. I. t.......	1	3	"	
37	37	" 14....	7:00 P. M.	P. H. I. t.......	5	3	Fair......................	
38	38	" 15 ...	4:00 P. M.	P. H. I. t.......	1	5	"	
39	39	" 16....	10:30 A. M.	P. H. I. t.......	2	3	Good	
40	40	" 17....	9:00 A. M.	P. H. I. t.......	2	3	Fair......................	
41	41	" 18....	8:00 A. M.	P. H. I. t.......	2	3	"	

Meteorological Data of Oyster Experiments.

DATE.	Hour.	Air temperature—Fahr.	Water temperature.	Tide.	Remarks.
June 2	11:30 A. M.	65	Creek, 67	Half flood	Clear and windy.
	1:00 P. M.	70			
	3:30 P. M.	71	Creek, 66	Highest.	
	6:00 P. M.	66			
	6:10 P. M.	64	....	....	Night cool.
June 3	NOON.	80	In pans, 70	Lowest.	
	4:00 P. M.	81	In pans, 73. On table, 77.		
	7:15 P. M.	74			
June 4	5:00 A. M.	57	On table, 56. In claire, 67.	First ebb.	
June 6	9:00 A. M.	68	68	Ebbing	Cloudy, easterly winds.
	NOON.	70	....	....	Slight rain in night.
June 7	7:00 A. M.	66	....	....	Strong S. W. wind "
	NOON.	70	....	....	Temperature steady.
June 8	9:00 A. M.	67	....	....	Heavy rain in night.
	11:00 A. M.	72			
	2:00 P. M.	75			
	5:00 P. M.	70	Creek, 70.		
June 9	8:00 A. M.	74	....	....	Calm and clear.
	9:20 A. M.	79			
	11:00 A. M.	78	....	Third ebbed.	
	2:00 P. M.	78			
	4:00 P. M.	76			
	6:00 P. M.	....	....	Lowest.	
	8:00 P. M.	72			
June 10	5:30 A. M.	68			
June 20	10:00 A. M.	69	....	Half ebb.	
	1:30 P. M.	68	Creek, 69	Half flood	Rainstorm breaks.
	3:45 P. M.	67	Creek, 68.		
	6:00 P. M.	....	....	Highest	Very high tide.
June 21	7:00 A. M.	66			
	9:30 A. M.	72			
	NOON.	78	In bowl, 74. In Claire, 70.		
	3:30 P. M.	75	In bowl, 70.		
	6:15 P. M.	....	....	Highest	Very high tide.
June 22	6:00 A. M.	58	In bowl, 56	....	Night cool.
	7:00 A. M.	64	In bowl, 58	....	Many mosquitoes.
	9:20 A. M.	68	In bowl, 63	....	Strong N. E. wind.
	3:45 P. M.	67	In creek, 72. In tumblers, 66.		
	5:00 P. M.	64	....	....	Very high tide.
	8:00 P. M.	....	....	Highest.	

Meteorological Data of Oyster Experiments—Continued.

DATE.	Hour.	Air temperature—Fahr.	Water temperature.	Tide.	Remarks.
June 23..........	6:00 A. M.	60	In claire, 66..........	....	Heavy N. E. storm.
	2:30 P. M.	62	....	Lowest..............	Temperature cool, steady.
	4:45 P. M.	60			
	8:45 P. M.	60	....	Highest..............	Storm tide.
June 24..........	11:30 A. M.	60	....	....	60° all day, storm tide.
June 26..........	9:00 A. M.	64			
	10:00 A. M.	67	In claire, 67..........	....	Muggy, cloudy.
	NOON.	70			
	6:00 P. M.	69	In claire, 68.		
June 27..........	7:00 A. M.	66	In claire, 68..........	....	Night cold.
July 8..........	11:00 A. M.	88	In claire, 77. In bowls, 81.		
	1:00 P. M.	92	In creek, 82. In bowls, 86.		
	3:00 P. M.	92	In bowls, 88..........	Lowest.	
	7:00 P. M.	82	In creek, 80..........	....	Mosquitoes bad.
July 9..........	6:00 A. M.	74			
	2:00 P. M.	94			
	7:00 P. M.	86			
July 10..........	7:00 A. M.	72	....	....	Cool morning.
	8:00 A. M.	84			
	NOON.	94	In tumblers, 88.		
	2:30 P. M.	94	In creek, 85..........	Two-thirds ebb.	
	5:30 P. M.	90	....	....	Thunderstorm.
July 11..........	9:00 A. M.	88	....	....	Mosquitoes terrible.
	9:30 A. M.	90			
	11:00 A. M.	90	....	Highest.	
	NOON.	86	....	....	Good wind.
	4:00 P. M.	84	....	....	Storm began.
	6:00 P. M.	78	....	....	Sultry.
July 12..........	6:00 A. M.	70	....	....	Cool morning.
	8:00 A. M.	80			
	11:00 A. M.	77	....	....	Storm.
	3:00 P. M.	....	....	....	Cloud burst, stormy.
July 13..........	7:30 A. M.	68			
	9:00 A. M.	....	....	....	Still stormy.
	NOON.	69			
	5:00 P. M.	69			
July 14..........	9:00 A. M.	70	....	....	Clear.
July 15..........	9:30 A. M.	72			
	NOON.	76			
	3:00 P. M.	....	....	....	High wind.
	6:00 P. M.	70	In creek, 75. In claire, 72	Low water.	

Meteorological Data of Oyster Experiments—Continued.

DATE.	Hour.	Air temperature—Fahr.	Water temperature.	Tide.	Remarks.
July 16	6:00 A. M.	58	In creek, 70. In claire, 68.	....	Cool morning.
	9:00 A. M.	70	In tumblers, 70.	Low, first flow.	
	2:00 P. M.	78	In creek, 70.		
	6:20 P. M.	74	In creek, 74. In claire, 72.	Low.	Mosquitoes troublesome.
July 17	8:00 A. M.	73			
	9:00 A. M.	....	....	Lowest.	
	10:00 A. M.	80			
	NOON.	84	In creek, 74. In tumblers, 79.		
	4:00 P. M.	82	In creek, 75. In claire, 72.	First ebb.	
July 18	7:00 A. M.	70	....	....	Night warm, cloudy, windy.
	11:00 A. M.	70	....	....	East storm.
	9:00 P. M.	70	....	....	Still stormy.
July 19	9:00 A. M.	75	In dishes, 70.	....	Windy.
	10:30 A. M.	76			
	11:00 A. M.	80			
	NOON.	82	Floated tumb., 78. In claire, 74.		
	6:15 P. M.	80			
July 20	8:00 A. M.	70	In claire, 72.		
	11:00 A. M.	74			
	3:30 P. M.	76			
	6:00 P. M.	76	In creek, 74.	Highest.	Very high tide.
July 21	7:00 A. M.	70	....	....	Cool morning.
	8:00 A. M.	74			
	9:00 A. M.	77			
	2:30 P. M.	84			
	6:30 P. M.	80	....	High.	
	7:30 P. M.	78	In jar, 78.		
July 22	6:00 A. M.	70	In jar, 72.		
	9:30 A. M.	78	....	Low.	Mosquito pupæ abundant.
	11:00 A. M.	80			
	2:00 P. M.	80	....	....	Storm in evening, cool.
July 23	9:00 A. M.	75	In jar, 70.	....	Mosquitoes hatched.
	NOON.	82			
	1:30 P. M.	84			
	4:30 P. M.	84	In jar, 75. In creek, 82.	Lowest at 3:30.	
	7:20 P. M.	78			
July 24	8:30 A. M.	76	....	....	Night cool.
	10:00 A. M.	80			
	3:00 P. M.	86	In jar, 76. In tumblers, 80.		

Meteorological Data of Oyster Experiments—Continued.

DATE.	Hour.	Air temperature—Fahr.	Water temperature.	Tide.	Remarks.
July 24	4:30 P. M.	86	....	Lowest.	
	6:00 P. M.	84			
	7:30 P. M.	79	....	....	Mosquitoes terrible.
July 25	3:30 A. M.	60	....	....	Night was cool.
	9:00 A. M.	77	In jar, 67. In bowl, 70.		
	10:30 A. M.	84			
	2:00 P. M.	83			
	6:00 P. M.	81			
	7:15 P. M.	74	....	....	Night sultry.
July 26	7:00 A. M.	70			
	8:30 A. M.	80			
	9:30 P. M.	81	In float, 77.		
	NOON.	92	Creek, 78	Highest.	
	2:00 P. M.	94	....	....	Thunderstorm gathers.
	7:30 P. M.	83	....	....	Mosquitoes bad.
July 27	7:30 A. M.	70	In jar, 68	....	Cool morning.
	9:00 A. M.	75			
	NOON.	80			
	4:00 P. M.	80			
	5:00 P. M.	78			
	7:00 P. M.	70			
July 28.	7:00 A. M.	60	....	....	Night cold.
	9:00 A. M.	72	Claire, 70. Tumblers, 62.		
	11:00 A. M.	76			
	1:00 P. M.	74	....	Highest.	
	5:00 P. M.	75			
	7:00 P. M.	70			
July 29	5:30 A. M.	72	....	....	Night warm.
	9:00 A. M.	78	....	....	S. E. storm threatens.
	NOON.	80			
	4:00 P. M.	80			
	6:00 P. M.	78	....	....	Rain begins.
July 30	5:00 A. M.	75	....	....	Humid S. E. wind, night warm.
	7:00 A. M.	76			
	10:00 A. M.	87			
	NOON.	88			
August 8	11:00 A. M.	70	In jar, 63.		
	NOON.	72	Creek, 72	Third ebbed.	
	7:00 P. M.	68			
August 9	9:00 A. M.	72	....	....	Night warm, rainy.
	10:30 A. M.	75	Creek, 73	Highest.	

Meteorological Data of Oyster Experiments—Continued.

DATE.	Hour.	Air temperature—Fahr.	Water temperature.	Tide.	Remarks
August 9	1:20 P. M.	78			
	2:30 P. M.	80			
	7:00 P. M.	75	Claire, 75	Half ebbed	Night warm, steady, 75.
August 10	9:00 A. M.	75			
	11:30 A. M.	80	Claire, 76.		
	6:00 P. M.	77			Night sultry.
August 11	9:00 A. M.	76			
	10:30 A. M.	78			
	NOON.	81		Highest	Rainstorm.
	2:00 P. M.	76			
	5:00 P. M.	77			
August 12	7:00 A. M.	70	Incubator, 75.		
	1:00 P. M.	81			
	5:45 P. M.	76			
August 13	7:00 A. M.	62	Incubator, 70		Cool morning.
	10:00 A. M.	73			
	NOON.	75			
	4:00 P. M.	72	Claire, 70.		
August 14	7:00 A. M.	75	Incubator, 78		Rain in night.
	10:30 A. M.	68	Claire, 70.		
	NOON.	68			Cold N. E. rain began.
	2:30 P. M.	76	Incubator, 75.		
	4:30 P. M.	77			
	7:30 P. M.	70			
August 15	7:00 A. M.	60			
	4:00 P. M.	74			
	8:00 P. M.	70			
	10:00 P. M.	70			
August 16	10:30 A. M.	72			
	NOON.	73			
	5:00 P. M.	72			
August 17	7:30 A. M.	68	In tumblers, 66. Incubator, 75.		
	11:00 A. M.	78			
	2:00 P. M.	78	In tumblers, 74. On incubator, 77.		
	4:30 P. M.	76		Highest.	
	7:30 P. M.	72			
August 18	8:00 A. M.	70			
	8:20 A. M.	76			
	9:00 A. M.	80	Incubator, 80.		
	11:00 A. M.		On table, 78.		
	7:00 P. M.	72			
August 19	5:30 A. M.	72			

TABLE OF EXPERIMENTS GIVING GOOD RESULTS.

The temperature given is that of the air, except for sieve in experiment 18. The hours when the shell was first seen are given, not the actual time of its origin. An incubator was used at night in the last four experiments.

		4.	6.	7.	8.	18.	24.	26.	31.	32.	33.	35.	41.
Date		June 6.	June 6.	June 8.	June 9.	July 15.	July 21.	July 23.	July 30.	Aug. 8.	Aug. 9.	Aug. 12.	Aug. 18.
Time		Noon.	Noon.	Noon.	Noon.	P. M.	P. M.	Noon.	Morn.	Noon.	Noon.	Morn.	Morn.
Tide		Ebb.	⅔ ebb.	½ ebb.	⅓ ebb.	High.	Flow.	Low.	½ ebb.	⅓ ebb.	¼ ebb.	High.	High.
Seed		H. I.	Nat.	E. R.	Nat.	H. I.	H. I.	H. I.	H. I.	H. I.	H. I.	H. I.	H. I.
History		P. 2d Cr.	P. Cr.	Cr.	P. Cr.	P.	Cr.	P.	P. Cr.	P.	P. Cr.	P. pt.	P. pt.
State		......	......	......	Clear hood.	Full.	Part spawned.	One good.	Good.	Good.	One fair.	Good.	Good.
Eggs		......	......	......	Good.	......	......	......	Good.	Fair.	Fair.	Good.	Fair.
Fertilization		......	Crossed. Mixed.	Several males.	......	Crowded.	Several males.	......	Careful.	Few sperms.	Several males.	Few sperms.	Few sperms.
Treatment		Lab. table.	Lab. table.	Lab. table.	Lab. table.	Sieve. 68°–70°	Lab. table.	Bowl Lab.	Lab. table.	Lab. table.	Lab and inc.	Lab., &c.	Lab. and inc.
Temperature extremes.	First day	70 66	70 66	75 70	74 79	76 70	84 78	84 78	75 88	72 80	80 Inc.	70 80	70 80
	Second day	70 67	70 67	74 79	68 80	58 78	70 80	76 86	......	72 80	80 Inc.	62 75	82 Inc.
Hours to shell stage		60	60	27	?	60	24	18	?	27	24	24	21
Miscellaneous		Cool weather, development slow.		......	......	......	......	Destroyed by rain-water.	......	......	......	......	Delayed fertilization.

TABLE OF EXPERIMENTS GIVING POOR RESULTS.

The temperature given is that of the air, except in case of "floated" and "incubated" eggs. E. R.—East River plants; H. I.—Hog Island (southern) plants; Cr.—Slopwater creek; E. C.—Elder creek; 6d.—six days transplanted; P.—Motte pond: G. B.—Great bay.

Number	1.	2.	3.	5.	9.	10.	11.	12.	13.
Date	June 2.	June 2.	June 3.	June 6.	June 9.	June 20.	June 22.	June 24.	July 7.
Time	Noon.	Evening.	Evening.	Noon.	Noon.	Noon.	P. M.	Noon.	A. M.
Tide	½ flood.	¼ ebb.	High.	Low.	½ ebb.	High.	Low.	½ ebb.	....
Seed	E. R.	Nat.	H. I. Nat.	E. R.	H. I.	E. R.	E. R.	E. R.	E. R.
History	Cr.	E. C.	P.	Cr.	P. 6d Cr.	Cr.	Cr.	Cr.	Cr.
State	Good.	Good.	Fair.	....	Good.	Good.	Part spawned.	Part spawned.	Spawned.
Eggs	Fair.	Crowded.	Poor.	....	Fair.	Good.	Fair.	Fair.	Fair.
Fertilization	Separate.	Several males.	Crossed.	Several males.	....	Several males.	Several males.	Several males.	....
Treatment	Floated. 69°.	Pockets. 64°.	Lab. table.	Lab. table.	Lab.	Floated.	Floated.	Floated.	Sieve.
Temperature extremes. First day	71	77 81	74 56	70 66	78 72	68	68	67	77
Temperature extremes. Second day	64 80	67 80	....	70	68	70	72	66	82
Fry	....	....	....	....	....	....	....	....	....
Remarks	Destroyed by rain-water.	....	Started well.	Retarded by cold.	....	Upset by tide.	Upset by tide.	Air cool.	Air very hot.

TABLE OF EXPERIMENTS GIVING POOR RESULTS—Continued.

The temperature given is that of the air, except in case of "floated" and "incubated" eggs. E. R.—East River plants; H. I.—Hog Island (southern) plants; Cr.—Stopwater creek; E. C.—Elder creek; 6d.—Six days transplanted; P.—Motte Pond; G. B.—Great bay.

Number	14.	15.	16.	17.	19.	20.	21.	22.	23.	25.
Date	July 10.	July 10.	July 15.	July 15.	July 18.	July 18.	July 18.	July 18.	July 18.	July 21.
Time	Evening.	Evening.	Morning.	P. M.	A. M.	A. M.	A. M.	A. M.	Noon.	P. M.
Tide	Low.	Low.	Low.	⅔ ebb.	Low.	Low.	Low.	Low.	⅓ flood.	½ flood.
Seed	Nat.	H. I.	E. R.	Nat.	H. I.	H. I.	E. R.	H. I.	E. R.	E. R.
History	P.	P.	Cr. bank.	P.	Cr.	P. pt.	Cr.	Cr.	Cr. bank.	Cr. bank.
State	Part spawned.	Good.	Good.	Part Spawned.	Good.	Hood clear.	Not ripe.	Part spawned.	Filled.	Filled.
Eggs	Fair.	Fair.	Light.	Light.	Good.	Good.	....	....	Fine.	Light.
Fertilization	Crowded.	Crowded.	....	....	Crossed.	Crossed.	Crossed.	Crossed.	Crossed.	Spent sperms.
Treatment	Sieve.	Lab. table.	Lab. table.	Lab. table.	Floated and lab.	Floated and lab.	Floated and lab.	Floated and lab.	Floated and lab.	Lab.
Temperature extremes. First day	80	90	76 70	76 70	73	73	73	73	73	84 78
Temperature extremes. Second day	85	88 90	58 70	58 70	75 70	75 70	75 70	75 70	75 70	70 80
Fry	....	....	....	Infusors.	....	....	....	....	....	....
Remarks	Upset by storm.	....	....	....	Spoiled by adding rain water.					No development.

TABLE OF EXPERIMENTS GIVING POOR RESULTS—Concluded.

The temperature given is that of the air, except in case of "floated" and "incubated" eggs. E. R.—East River plants; H. I.—Hog Island (southern) plants; Cr.—Stopwater creek; E. C.—Elder creek; 6d.—Six days transplanted; P.—Motte Pond; G. B.—Great bay.

Number	27.	28.	29.	30.	34.	36.	37.	38.	39.	40.
Date	July 23.	July 24.	July 27.	July 28.	Aug. 11.	Aug. 13.	Aug. 14.	Aug. 15.	Aug. 16.	Aug. 17.
Time	Noon.	P. M.	Morning.	A. M.	Evening.	P. M.	Evening.	P. M.	A. M.	A. M.
Tide	½ ebb.	Low.	Low.	½ flood.	½ ebb.	High.	½ ebb.	High.	High.	High.
Seed	H. I.	H. I.	H. I.	H. I.	H. I.	H. I.	H. I.	H. I.	H. I.	H. I.
History	Cr.	Cr. 1d.	P. pt.	P.	P. Cr.	P. pt.	P. pt.	P. pt.	P. pt.	P. pt.
State	Poor.	Part spawned.	Fine.	Fine.	Spawned.	Good.	Fair.	Fair.	Good.	Good.
Eggs	Poor.	Fair.	Crowded.	Fine.	Poor.	Good.	Fair.	Fair.	Good.	Fair.
Fertilization	Crossed.	Several males.	Several males.	....	....	Careful.	Several males.	....	Few sperms.	Few sperms.
Treatment	....	Lab.	Floated.	Lab.	Lab., &c.	Lab., &c.	Inc.	Lab.	Lab. inc.	Lab. inc.
Temperature extremes. First day	84 75	86 79	70 80	70 76	77	72	75	70	72 80	78
Temperature extremes. Second day	80 86	60 84	....	70 80	70 81	70 76	80 70	73	78 72	82 76
Fry	....	....	Infusors.	Infusors.	....	Decomposed.	Abortive.	Infusors.	Infusors.	Infusors.
Remarks	....	Killed by rain-water.	....	Rain-water.	....	Not well cleaned.	Few in shell.	G. B. water.	G. B water.	....

Distribution of the causes of failure in twenty-nine unsuccessful experiments:

1. Subjected to influence of low-tide water, in five cases.
2. Subjected to influence of too low temperature, in four cases.
3. Subjected to influence of too high temperature, in two cases.
4. Overcrowding eggs, in two cases.
5. Poor eggs, because partly spawned, in seven cases.
6. Addition of rain-water, in eight cases.
7. Use of spent sperms, in one case.
8. Imperfect cleaning, in three cases.
9. Poor ventilation, in three cases.
10. Cannot explain, in three cases.
11. Destroyed by accidents, in three cases.

In the above resumé only the most prominent influences that affected the experiments have been noted. In several cases there was more than one untoward condition at work. Some of these have been included in the synopsis, and hence the above figures will sum up greater than the entire number of experiments.

The high number destroyed by rain-water is due to the fact that this was tried at one time on five simultaneously progressing experiments.

EXPLANATION OF THE PLATES.

[Scale or enlargement is indicated on each plate or figure.]

PLATES I. AND II.

Map of the region surrounding the Tuckerton Oyster Experiment Station.

PLATE III.

Camera lucida drawings of the gregarinoid parasites of oysters, after preparation by alcohol fixation, magenta staining and balsam mounting.

Figure 1. Eggs. 2 to 8. Various stages of segmentation and growth.

Figure 9. Embryo, showing the cuticular membrane broken.

Figure 10. Beginning of the arms. 11. Later stage.

Figure 12. Eggs show in the interior.

Figure 13. Later stage, showing chromatin corpuscles in the "head."

Figure 14. "Head" enlarged, showing the chromatin cells, and also showing that arms break off.

Figure 15. Supposed arm, at a later stage, when it is greatly enlarged after detachment.

Figure 16. Body, after head and arms have been lost, showing multiplication of embryos within. They appear to be set free by dissolution of the body.

Figure 17. Head and arms detached at an early stage; perhaps accidental.

PLATE IV.

Figure 1. Preparation of gregarinoid parasite of oyster to show early stage of development of embryos within its body.

Figure 2. Drawing from living specimen, showing arms detached; perhaps accidentally.

Figure 3. Drawing from living specimen, with arms moderately developed. Figures in our report for 1902 show that these arms ordinarily grow to great length before being detached. Living specimens show vermiform bendings of the body.

Figures 4 and 5. Two infusors found in preparations of developing oyster fry. In Figure 5 various "food balls" are seen within the body, and one such "ball" is being swallowed. The mouth is near the pointed end.

Figures 6 and 7. Supposed embryo of clam (*Venus mercenaria*), showing velar disk at *v* and umbo at *u*.

Figures 8 and 9. Shell-stage oyster fry from the creek, as produced by nature; in late stages, before fixation. Figure 9 shows a peculiar clear area at the umbo, and a thickened area, bounded by a ridge, on the remaining portion of the shell. Cilia in Figure 8 are shown as they appear when in motion.

Figures 10 to 21. Various mounted and stained preparations of infusoria from oyster experiments. These are generally present in all the cases that give poor results.

Figure 15 is probably a group of infusorial spores, and Figure 18 a fragment of a decomposing oyster embryo, whose cells are nearly of the same size as the infusorial spores. The dark bands and bodies in the infusoria are composed of chromatin and are nuclei.


NEW GRETNA
ROAD
BASS RIVER
Wolf Run
Ballangers Cr.
Roundabout Cr.
Iselands Thoro
Bridge
SOOY I.
MULLICA RIVER
CHESTNUT NECK
NACOTE R.
GREAT BAY
Marsh.
1 Mile
scale
To Port Republic
ROAD TO ABSECON
Leeds Point

PLATE I.

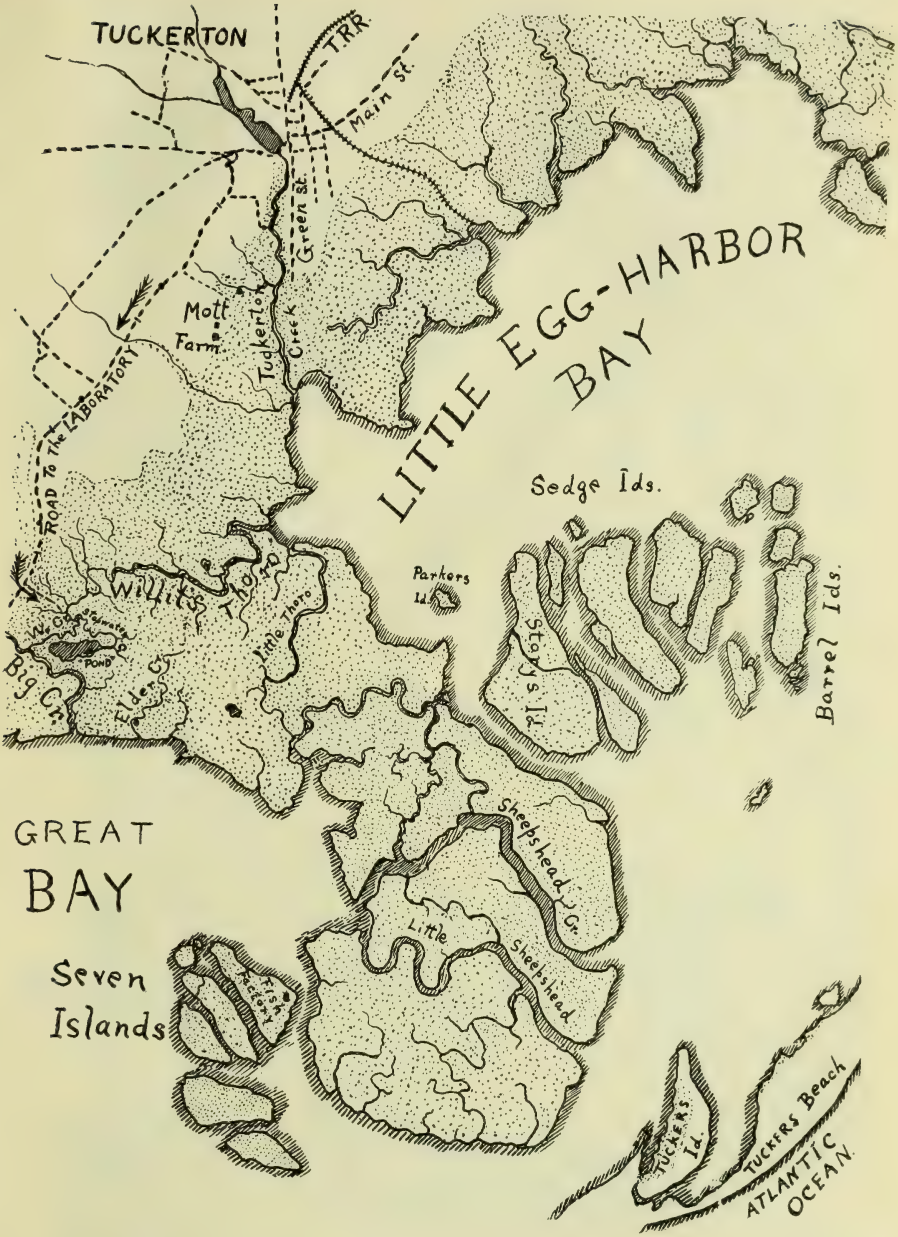
TUCKERTON
T.R.R.
Main St.
Green St.
Mott Farm
Tuckerton Creek
ROAD TO THE LABORATORY
LITTLE EGG-HARBOR BAY
Sedge Ids.
Parkers Id.
Barrel Ids.
Willits Thoro
Little Thoro
Big Cr.
Elder Cr.
POND
Stays Id.
Sheepshead Cr.
Little Sheepshead
GREAT BAY
Seven Islands
Fish Factory
TUCKERS Id.
TUCKERS Beach
ATLANTIC OCEAN

PLATE II.


Scale
1/10 mm.
15
13
9
10
2
6
1
3
6
9
7
5
8
6
3
8
8
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12
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17
16
14
15

PLATE III.

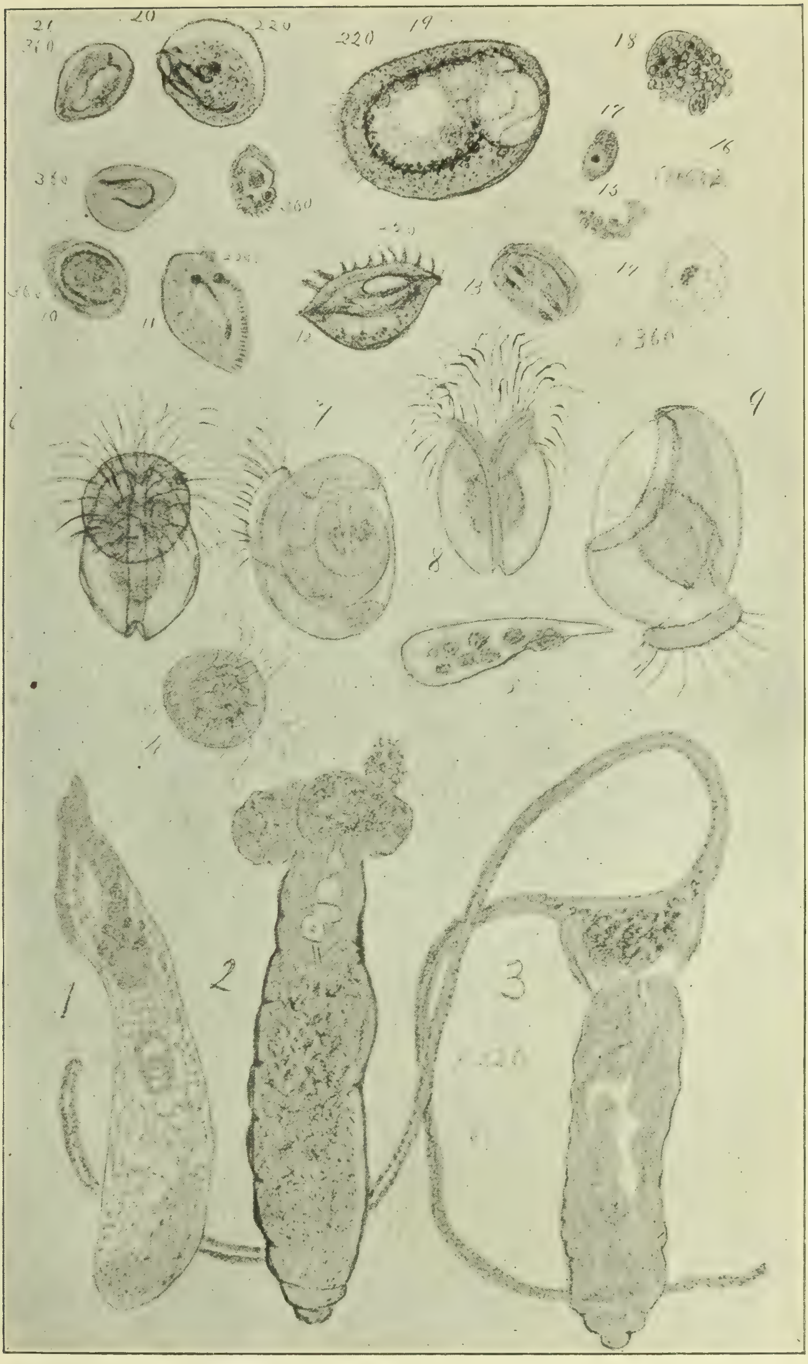


PLATE IV.

REPORT OF THE BOTANIST.

REPORT OF THE BOTANIST.

BYRON D. HALSTED, SC.D.
JAMES A. KELSEY, M.SC., FIELD ASSISTANT.

The work in the Botanical Department for the year ending November 30th, 1903, has been chiefly along lines mentioned in the reports for the past few years.

Plant breeding has been a leading feature of the work in the field, supplemented by that of the greenhouse. During the year a new variety of sweet corn has been established, which resulted from crossing the "Black Mexican" upon the "Egyptian." This combination has produced a variety with good-sized plants, and ears of satisfactory size and number of rows of graining upon the cob. The color of the green corn when ready for market is a rich pink, and therefore especially attractive. Progress has also been made in developing a variety of corn that may have the grains mixed in the ear—pink and white —and with a special tendency to produce more than two ears to each plant. During the season a cross has been secured between the "Black Mexican" and the "Country Gentleman" for future development by selection.

The crosses between eggplants, effected some seasons ago, have developed into one sort that seems reasonably fixed. During the present year crosses have been made between three Japanese varieties and some of our own standard sorts.

Among lima beans, the work of selection and fixing the peculiarities of certain crosses is going on. In this connection a test was made of the standard sorts that brings out important facts, particularly concerning susceptibility to the mildew, which was unusually abundant the present season.

Considerable of the Experiment Area was devoted to tomatoes, and at least one new sort is developed, namely, a yellow kind, that combines the qualities of two standard varieties and with tendencies that suggest it as a good breeder for further desirable points. The work

of reducing the seeding tendency is going forward, with hope of success in that direction.

The stability of the hybrid salsifies is being tested and new hybrids are each year being secured for a study of their economic value.

The several plots of corn gave an opportunity of growing and obtaining crosses between a number of varieties of squashes. No immediate effect of foreign pollen was observed, and no crosses, after many trials, were secured between the winter and summer varieties.

Considerable attention was given to hybridizing daturas, both in the greenhouse and the field. The weedy species seem to impress their characters upon the hybrids almost to the exclusion of the parent representing the ornamental kind.

The Drummond phlox has been bred in the field and many types of the fringed flowers have been obtained, with colors ranging from pure white to dark red.

This phlox has proved to be one of the best subjects for the study of fungicides for mildew in the greenhouse.

The facilities for laboratory and herbarium work have been much curtailed by the fire in the Station building and the consequent removal to other quarters for a larger part of the present year. The usual number of specimens have been secured and will be installed when the collections are returned to their former places.

The subject of powdery mildews has been one for study from the standpoint of number, kinds, distribution and destructiveness in the United States.

On account of the exceptional weather and the unusual prevalence of decay in potatoes, tomatoes, etc., the ailments of these crops have commanded some attention in the present report, and tables of rainfall, temperature and sunshine have been constructed, covering the past fifteen years.

Observations have been made from time to time upon asparagus rust, and data accumulated by correspondence as to its spread throughout the United States.

Weeds have been unusually abundant this year, and some space is given to this subject in the body of the report.

Bulletin No. 167: "Some of the Newer Fungicides," of sixteen pages, and two page-plates, was published June 29th, 1903.

The details of the work, both at the greenhouse and in the Experiment Grounds, have been, as formerly, in charge of Mr. J. A. Kelsey,

to whose faithfulness any success in breeding plants and other pains-taking operations is largely due. Sickness on the part of the writer has prevented him from giving the usual amount of attention to the department.

The Experiment Area.

The plan upon the opposing page shows the method by which the Experiment Area of two acres has been divided and the location of the several crops that occupied the ground the present season.

The ends of the piece of land are brought to a rectangle with the long parallel sides, and then paths four feet wide, running the short way, cut the land into seven series. Each of these series is again divided by three two-foot paths, running the length of the area, thus making the twenty-eight plots, each 33 by 66 feet, and containing one-twentieth of an acre.

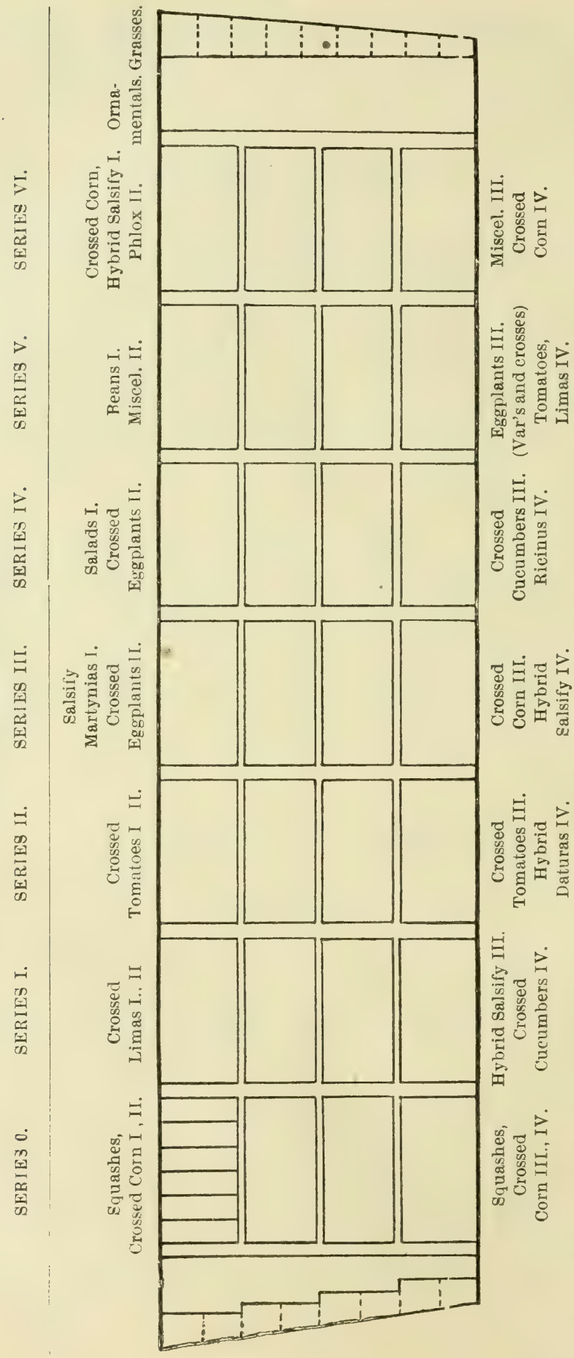
The soil is fairly uniform in quality throughout, it being a mixture of clay and gravel and not the best for garden purposes. Its texture has been improved by the application of stable manure at the rate of twenty tons per acre for the past nine years. During the last five years the manure has been placed in heaps of ten or twenty tons, and, when well rotted, added by measure to the several plots just before plowing or spading in the spring.

EXPERIMENTS WITH SWEET CORN.

The experiments in the crossing of sweet corn began in 1898, by planting the following sorts in the same plot: "First of All," "Stabler's Nonpareil," "Stowell's Evergreen," "Egyptian" and "Black Mexican." Cross-fertilization took place freely between the "Black Mexican" and the "Egyptian," some ears of the latter showing fully one-half of the grains of a dark color, indicating the effect of the former variety, the only one that was not white. It was observed that the dark color was less impressed upon the crossed grains of the "Stowell's Evergreen" than the "Egyptian." This suggested that the "Black Mexican" was more potent upon the "Egyptian" than upon the "Stowell's Evergreen," and led to the selection of the first two named sorts for future breeding.

In 1899 Plot II., Series III., was planted again to sweet corn,

The Experiment Area.



The Experiment Area for 1903.

there being a row each of the "Black Mexican" and "Egyptian" in each of the six belts. The "Black Mexican" is a variety of medium stature of plant, and also medium in time of maturing, with eight-rowed ears and grain of good quality, but sometimes objected to because of the dark color. The "Egyptian" is a larger sort, with heavier ears and white grains, in ten to sixteen rows, maturing comparatively late, and of high quality.

During this first season of the cross not more than one grain in fifteen of the "Mexican" showed the influence of the "Egyptian." Five of the most affected ears gave a total of 1,093 black grains to 299 of white ones. There was more of the mixing upon the "Egyptian," as a corresponding five ears show black grains, 1,083, and white, 1,385. A comparison of the two sets of figures also shows the relative size of the ears of the two sorts. With the "Egyptian" crosses there were all gradations between the slightly purplish grains and those that were nearly as dark as those of the typical "Mexican," and many were of a rose or pale-red color. Occasionally a grain was found with one-half white and the other dark, and in a few cases the division line was along the narrow way of the grain and suggesting a birth-mark, covering one side of the face.

Experiments in 1900.

During the season of 1900 four plots were in sweet corn as a continuation of the crossing of the previous year. Plot IV., Series IV., was planted with pink grains from single ear of the "Egyptian" type. The good qualities of the two varieties under consideration stood in favor of the "Egyptian." For example: a ten or twelve-rowed variety is preferred to one with only eight rows, and for this and other reasons the above choice in the cross was made. This plot made a fine showing of strong corn plants, and from the ninety-six hills, 355 good ears were gathered, there often being two ears to the best stalks, and sometimes three or four. The ears were, without exception, remarkably uniform in the even mixing of the white and colored grains. Five average ears gave an average of 172 white grains to 213 that were colored. There is a blending of the two parent varieties in the shape of ear, number of rows, as well as in a large percentage of pink grains. The slender "Mexican" type is not fully maintained in even the few eight-rowed ears, the cob being larger, with the basal end

somewhat swollen. The number of twelve-rowed ears exceeded all others, numbers which ranged from eight to sixteen showing that the mother plant ("Egyptian") had a very decided influence.

Experiments in 1901.

Plot IV., Series VI., was again planted to sweet corn, and the seed used was the pink grains from eight ears of the previous crop, and all having over ten rows upon the cob. The plants thus produced were remarkable for their vigor and size. At harvest time the first things observed was the greatly increased amount of red in the ears. The average of five typical ears gave 90 white, 81 black and 261 red grains. The number of grains per ear had increased considerably over the previous year, a feature of no small consequence when many rows is an advantage in sweet corn.

A greater variation in the ears was observed. In 1900 the ears were practically alike, but this season they ranged all the way from those with about half white grains to those in which the color was entirely red. It was also noted that nearly all the ears were more than eight-rowed, and this characteristic of the "Mexican" variety is largely lost from sight.

Experiments in 1902.

For the third successive season Plot IV., Series VI., was planted to sweet corn. From the previous crop a fine, solid-red, ten-rowed ear was selected and marked "X" ("Extra") at the time of harvest. For this some grains were taken, and a dozen plants grown in the greenhouse during the winter of 1901–2. Several ears were thus produced, all short, however, because of the unfavorable conditions for the best growth of corn, and from these, which were solid red, seed was selected for one-third of the plot, namely, belts 1 and 2. The remaining two-thirds of the plot was planted with grains from the ear marked "X"—that is, the mother ear of the greenhouse corn above mentioned. In other words, the whole plot was planted with the product of the same year; only the first two belts bore plants one generation further from the original cross of "Black Mexican" and "Egyptian." The greenhouse-grown seed produced smaller plants than in the other portion of the plot, a difference to be attributed to

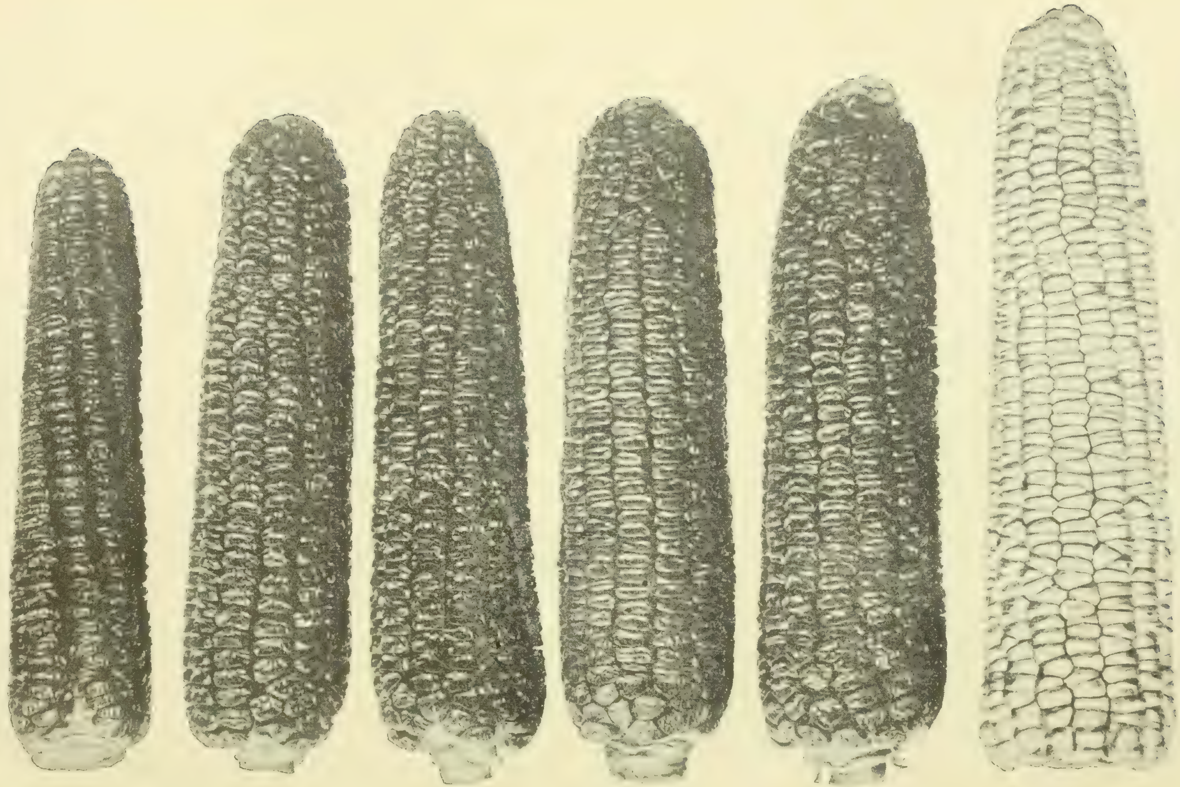


PLATE I.

Four ears of Voorhees Red Sweet Corn, with ear of male parent, "Black Mexican," upon the left, and an ear of the mother plant, "Egyptian," upon their right.

the poor conditions under which the seed was produced under glass. The ears, however, were not far below normal size.

At harvest time the first thing to be observed was the very large number of red grains, the average of five typical ears from the greenhouse seed being: white, 14; black, 0, and red, 373 grains; and of the same number of similar ears directly from the ear "X," white, 28; black, 0; red, 465. These figures show that the greenhouse grains produced less white kernels and somewhat smaller ears than the grain directly from ear "X."

It is seen that only a small percentage of white grains remains in this crop, which is from the planting of pink grains of a single ear of the "Egyptian" type in 1900.

The following table gives the number of rows for the best ears in the two portions of the plot.

	Greenhouse Progeny.	Direct from Ear "X."
No. of 8-rowed ears	3	6
" " 10 " "	10	15
" " 12 " "	42	38
" " 14 " "	15	14
" " 16 " "	6	6
Total	76	79

A little more than half (80 in 155) of these ears have twelve rows, and this is a number that is satisfactory in sweet corn.

Experiments in 1903.

For the fourth year in succession Series 0 was planted to corn, each of the four plots receiving grains from separate selected solid red ears of the previous crop. The season was unusually unfavorable for corn, it being exceedingly dry at the proper planting time and throughout May, to be succeeded by heavy rains in June and August, with winds that prostrated plants time and time again before harvest time. The yield was necessarily light, but from the size of the stalks and ears it was evident that under ordinary circumstances the crop would have been satisfactory. The number of solid red ears was very large, and seed has been selected from the best of these for future planting. Four sample ears are shown in Plate I., and upon the left is shown an ear of the male parent, "Black Mexican," and

upon the right, a corresponding ear of the female parent, the "Egyptian." The former is black and the latter white, and the resulting cross red; the former is eight-rowed and the latter ten to fourteen, with which the cross agree in this respect.

The Director of the Experiment Station has kindly consented to the use of his name in connection with this new variety, and therefore it will be known as the "Voorhees Red Sweet Corn."

Developing a Prolific Corn.

In 1901 a half of Plot III., Series IV., was planted somewhat late (June 28th), with grains taken from seven ears borne by three stalks of the cross-breed of the previous year. One of the stalks had three fine ears, while the other four of the seven ears were first-grade twins. The triplet had two ears with ten rows of grains and one ear with fourteen rows. One twin had eight and ten rows to the ear, respectively, while the other pair were both twelve-rowed. These ears were all quite uniform in the ratio of white to dark grains—that is, as 4 to 5.

The forty-eight hills from this seed, planted without regard to color, yielded forty-four stalks with single ears, unusually large and invariably with ten or more rows; eighty-three stalks with two marketable ears, each with rarely less than ten rows, and seventeen stalks with three or more ears, among which was one with five ears, all over five inches long; one with six and one with seven ears, but of these only one or two were marketable. The total number of ears was 272, or nearly an average of two ears to each stalk, exclusive of many abortive attempts to produce more.

It is noted that the mixed red and white result is still maintained, but it is not as uniform for all the ears as in the previous year, as shown in the other engraving of the same plate. In 1901, in other words, some stalks show more white than others. The average number of rows of grains to the ear is ten, which is practically the same as for the ears from which the seed was taken for planting.

In 1902 a whole plot was given to a further study of prolific corn. Single-eared stalks were rarely met with, the main portion having either two or three ears. It is observed that the mixture of white and red grains is maintained, but some variation in ration among the four lots of ears. When a stalk bears more than three ears it is at a

loss of commercial value of the product. There is difficulty in selecting seed for future planting, as there is a possibility of developing the tendency to produce ears beyond the limit of most profitable output of marketable ears.

During the present year Plot III., Series IV., was planted with "prolific corn," and the crop would have proved more satisfactory but for the very poor season. As it was, the late planting and heavy rains and windstorms gave a poor yield. There was a large percentage of stalks with two marketable ears, although many of them were small. There were strong indications of prolificness in stalks that had set three, four and even five ears, but usually they did not mature.

The ears at harvest showed a very even mixture of the white and pink grains, and by planting half of each of the two colors it may be possible to continue this mixture until it become a characteristic, so long as one or the other color is discarded in planting.

Crossing Corn—New Series.

Upon a half of Plot I. and the whole of Plot IV., Series VI., corn was again grown, but this time it was the beginning of a new series of crosses. The two varieties selected were the "Black Mexican" and the "Country Gentleman." The former has been used in the crosses with the "Egyptian," which gave rise, aided by selection, to the red sort that has taken the name of "Voorhees." It is, as often before stated, a black-grained variety, medium in size of plant and time for maturing, and with eight rows to the ear. It is of high quality and would be much more grown for the table were not its dark color an objection. The "Country Gentleman" is a white-grained sort, somewhat larger in plant and ear than the "Mexican," about two weeks longer in coming into bloom, and there are no well-defined rows, the numerous, long, pointed variable grains of high quality being very irregularly disposed upon the large cob.

In order to bring these two quite widely different varieties together and accommodate them as to time of blooming, they were planted in alternate rows, three rows apart, and after two weeks another similar planting, while the third planting, four weeks after the first, completed the plots.

The two sorts are easily distinguished as standing in the field, and one of the constant characteristics of the "Country Gentleman" was the handsome pink color of the silk, it being the white sort, while the "Black Mexican" had usually a pale green silk, although this is not constant, and some of the stalks bore pink silks—a variation that has been constantly met with in this variety.

There is little else to dwell upon for the present, except to show average ears of the parents and those in which the crossed grains are apparent from the mixture of the colors.

Plate II. shows a set of ears of corn that represent the "Black Mexican," upon the left, and the "Country Gentleman," upon the right. The next ear upon the left is a "Black Mexican," with a few grains only that have resulted from pollination of the "Country Gentleman," and the ear next to the right shows a larger percentage of this crossing. The right of the two middle ears is a "Country Gentleman" that resulted from hand pollination, and all its grains show the dark color that this crossing with the "Black Mexican" produced. To the right of the last-named ear is one which shows the mixing that was quite general in nearly all the ears of this sort.

The "Black Mexican" is an eight-rowed variety, but it sometimes happens that this number is somewhat increased, as instanced in ear that is next to one of the "Country Gentleman." The ordinary ear, when broken, appears as shown in the plate. The much longer and narrower grains of the "Country Gentleman" are similarly shown. This latter sort has pearly white grains that are disposed without apparent order upon the cob—that is, there are no distinct rows. It produces a larger ear than the "Black Mexican," and the ear required, in this experiment, fully two weeks more for it to reach marketable size. This was a very unusual season, and any tests as to periods of growth are not conclusive. With us the planting was much delayed on account of bad weather, and later on heavy floods and very destructive winds nearly ruined the experiment. This accounts for the comparatively small ears that appear in the picture. The unusual season may account for a fact that was painfully apparent at harvest time, namely, that but very few of the "Black Mexican" ears showed any white grains due to the pollen of the "Country Gentleman," while, on the other hand, it was almost impossible to find an ear of the latter sort that did not have dark grains due to the pollen of the "Black Mexican," all of which prevented the

PLATE II.

An ear of "Black Mexican" Corn shown upon the left, and one of "Country Gentleman" upon the right, with two ears of each variety between, showing crossing of the two varieties.

ears in the plate from being up to the average of the meagre crop. As the matter now stands, the "Country Gentleman" is easily fertilized by the "Black Mexican," while the latter is with rare instances crossed upon by the "Country Gentleman." In other words, the "Black Mexican" is highly prepotent, as determined in other experiments. It was observed that the dark grains of the "Country Gentleman" were not usually of the same shade as the full "Black Mexican," but instead inclined to a lead color. The white grains upon the "Black Mexican" were, with few exceptions, as light as those of the full "Country Gentleman."

The quality of the two varieties is superior, as determined by actual test by those who are able to judge of the culinary merits of this vegetable.

Further Observations Upon Salsify Hybrids.

The salsify to which the most attention was given the past season was that in Plot IV., Series III., consisting of hybrids of *Tragopogon porrifolius* L. and *T. pratensis* L. Twenty-one rows were planted here in August, 1902, the seed for the first eight being from first-generation crosses produced that season in Plot III., Series IV., while that for the remaining thirteen was produced by third-generation hybrids in Plot I., Series VI. Rows 1 and 2 were offspring of hybrids that appeared in rows of *T. pratensis,* while the hybrid parents of rows 3 to 8 were developed among plants of *T. porrifolius.* The seed planted in rows 9 to 21 was gathered from second-generation hybrids in Plot I., Series VI., and represented the following colors of Prang's list: 21, 22, 31, 41, 92, 224, 225, 233, 243, 333, 355 and 384.

The stand of plants was fairly good, and the season's color record, including about 700 plants, is herewith given. Rows 1 and 2:

Parent type	93	Yellow	18
	234	Light red violet	1
	243	Red red violet	9
	243	" " " (center yellow)	10
	243	" " " (center mottled)	3

There was one "Albino" plant and one with flower heads changed to green.

Rows 3 to 8:

Parent type	93	Yellow	12
Parent type	224	Light violet red violet	2
	225	Lighter “ “ “	2
	233	Red violet	1
	234	Light red violet	12
	234	“ “ “ (center mottled)	7
	235	Lighter red violet	2
	235	“ “ “ (center mottled)	1
	242	Dark red red violet	2
	242	“ “ “ “ (center mottled)	1
	243	Red red violet	12
	243	“ “ “ (center mottled)	14
	253	Orange gray (brown) (center yellow)	1
	333	Red gray (russet)	4
	333	“ “ “ (center mottled)	1
	335	Lighter red gray (russet)	1

There was one “Albino.”

Rows 9 to 21:

	21	Darker red red orange (center yellow)	1
	21	“ “ “ “ (center mottled)	5
	22	Dark red red orange (center yellow)	1
	31	Darker red orange	7
	31	“ “ “ (center yellow)	21
	41	Darker orange red orange	3
	41	“ “ “ “ (center yellow)	1
	41	“ “ “ “ (center mottled)	1
	61	Darker orange yellow orange	1
	61	“ “ “ “ (center yellow)	1
	61	“ “ “ “ (center 243)	1
	82	Dark yellow yellow orange	1
	92	Dark yellow	1
Parent type	93	Yellow	98
	95	Lighter yellow	2
Parent type	224	Light violet red violet	6
	225	Lighter “ “ “	19
	233	Red violet	14
	234	Light red violet	120
	234	“ “ “ (center yellow)	6
	234	“ “ “ (center mottled)	6
	234	“ “ “ (center light)	43
	243	Red red violet	39
	243	“ “ “ (center violet)	46
	243	“ “ “ (center mottled)	28
	244	Light red red violet	1
	244	“ “ “ “ (center yellow)	1
	253	Orange gray (brown)	4
	254	“ “ “ (center yellow)	5
	325	Lighter violet red violet	1
	333	“ “ “ “	12
	333	“ “ “ “ (center yellow)	19
	333	“ “ “ “ (center mottled)	2
	334	Light red violet	3
	334	“ “ “ (center yellow)	22
	335	Lighter red gray (russet)	1
	335	“ “ “ “ (center yellow)	3
	354	Light yellow gray (citrine)	4
	355	Lighter “ “ “	5

A mixture of seeds, representing the various colors in rows 9 to 21 was planted in Plot III., Series III.

No attempt was made to record the number of hybrid plants of different colors in Plot I., Series VI., but it can be said that all the colors recorded in the plot just considered were observed here, and as a whole there seemed to be no striking contrast between the two plots.

An attempt was made the past season to cross *T. pratensis* and *T porrofolius* with their hybrids, and also with Scorzonera or "black salisfy." The seeds from flowers thus pollinized were sown in Half-plot I., Series III.

EXPERIMENTS WITH EGGPLANTS.

In 1900 cross-pollination was effected between the "New York Improved Spineless" variety of eggplant and one that is known as "Early Long Purple." The new greenhouse provided for the propagation of a large stock of plants from the seeds of fruits that resulted from the above work in crossing. The following season was unusually favorable for the growth of eggplants, and two plots were occupied with the crosses, while other portions of the area contained specimens of the parent species, grown for sake of comparison. The cross was early manifest in the upright habit of the "Long Purple" and the large, broad leaf of the "New York Improved."* There was the purple color of the young stems and leaf-stalks of the former combined with the stoutness of the latter variety. The vigor was so remarkable that it suggested the idea that crossing of varieties might be of importance for this point alone.

When the fruits reached marketable size the evidence of a cross was confirmed, because instead of the long, slender and usually curved form of the "Long Purple" or the nearly oval shape of the "New York Improved," there was a fruit that closely combined the characteristics of the two and produced a shape agreeing with that of the "Bartlett" pear. In weight it was heavier than the "New York Improved," and agreed with it in color. No change in this latter feature was expected, because both parents were of a handsome purple color.

A serious objection to the "Long Purple," as grown here for years, is the lateness in coming into bearing. The fruits, although of high

*The term "Spineless" of the full, long trade name is omitted because the "spines" were much in evidence.

quality, are small, and altogether the variety is not profitable. The large slices of the oval fruits of the "New York Improved" are not well suited for the frying-pan, while the longer and smaller fruit of the cross are of a convenient size for cooking and the table.

The cross has a desirable size and shape and is an improvement upon the "New York Improved" in its superior quality. In the "Long Purple" the seeds are confined to the lower half of the fruit, and the cross under consideration holding to this characteristic gives two-thirds of its fruit free from seeds, and therefore several slices that are solid flesh.

A striking fact in connection with this cross, in its first season, was it earliness, for its plants began to yield marketable fruits on July 20th, while it was August 8th before they could be gathered from the "New York Improved," and were rare upon the "Long Purple" until after September 10th.

In 1902 the crossed eggplants occupied Plot II., Series II., and Plot II., Series III., and were the representatives of four selected fruits of the previous crop. The plants were thrifty, and it was observed that toward the close of the season the parent sorts ceased blooming, while these crosses blossomed freely up to the time of frosts, and then the plants contained many young fruits. It was noted that the general shape, previously mentioned, was adhered to and not over 10 per cent. of the plants produced fruits of the "New York Improved" type, while none were long and slender like those of the "Long Purple." During this season no less than eighteen commercial varieties, all that could be readily procured, were grown to compare with the new cross, and while there were several that seemed alike, none of them resembled the cross either in great vigor of plant or shape of fruit. Several cross-pollinations were made between some of the widely separated forms, as the "Black Snake," a long, slender and crooked fruit, and "Round White," a handsome fruit, about the size of an egg, and the standard sorts, as "Black Pekin," and the "New York Improved."

Eggplants in 1903.

The work with eggplants the past season was devoted chiefly to crossed stock occupying the greater part of three plots, namely, Plot II., Series III., Plot II., Series IV., and Plot III., Series V. Un-

favorable weather prevailed throughout the summer, and the plants grew slowly and were later than usual in producing fruits of a marketable size. The same conditions seemed to be equally unfavorable for the development of the leaf-blight and fruit-rot, usually so injurious to this crop. The foliage of the Experiment Area plants was practically unharmed, and the fruit-rot did not make its appearance until late in the season, and developed much slower than usual. No fungicides were applied during the summer.

The two plots in Series III. and IV. contained about 200 eggplants, representing the third generation resulting from the crosses made in 1900 between the "New York Improved" and "Early Long Purple" varieties. The seed producing this season's stock was taken from fifteen selected fruits of the crop of 1902. The number of plants from a single fruit varied from ten to about sixty.

No record was kept of the number of fruits produced, but the third-generation stock began fruiting as early and were as productive as plants of the parent types. Some of the fruits resembled in form and size those of the original parents, but the majority were noticeably different and more or less bell-shaped.

In the first half of Plot III., Series V., the following varieties of eggplants were grown the present season:

1. "New York Improved."
2. "Black Pekin."
3. "Early Dwarf Purple."
4. "Round French."
5. "Striped."
6. "Delicatesse."
7. "Round White."
8. "Mammoth Pearl."
9. "Black Beauty."
10. "Early Long Purple."
11. "Long White."
12. "Black Snake."
13. "Japanese."
14. " No. 9,297.
15. " " 9,298.

Many of the above varieties were grown in the Experiment Area in 1902 and were briefly described in the report for that year (pages 384–5). The "Black Beauty" variety was given a more satisfactory trial this season and is a desirable sort. In number and form of fruits it resembles closely the "New York Improved," but of larger size.

Japanese Eggplants.

Of the three Japanese sorts, No. 9,298 is the only one that showed much value. It resembles closely the "Black Pekin" variety. The other two have not been especially productive, and their fruits have been too small to be of any particular value. All three of the Japanese varieties have been crossed with the "New York Improved," and results of such crosses may be reported later.

Plate III. shows the three types of Japanese eggplant fruits. The first lot of six plants to the left are from seed sent direct from Tokio, Japan, by Mr. D. G. Fairchild, in letter under date of June 3d, 1902. It is seen to be a very slender fruit and usually much bent or twisted. The sort shown in the middle of the plate is from seed sent out by the Government under the list number 9,297, and is elongated pear-shaped. The third bears the Government number 9,298, and is a nearly round variety, and, as before stated, resembles the "Black Pekin" in shape, color and size.

New Crosses of Eggplants.

The following new crosses of eggplants were grown the present year:

1. "New York Improved" upon "Black Snake" gave fruits that were ten to twelve inches long and three to four inches wide. The color is like both parents and therefore purple. The quality is excellent and the shape is desirable from the culinary standpoint, as it permits of numerous slices of acceptable size for cooking and serving. On account of the shape of the fruit they rest by the lower end upon the ground and are less liable to decay than the round sorts.

2. "Long White" upon "New York Improved" gave fruits varying much in color and shape, as the parents were quite unlike in these respects. The curved form of the male parent was present in many of the crosses, while its white exterior blended with the purple of the mother plant in producing a variegated surface, some fruits being spotted white and purple, others somewhat striped, and others of a nearly solid shade of green.

3. "Round White" upon "Black Pekin" gave fruits that in variety of colors were nearly the same as in No. 2, there being a blending of

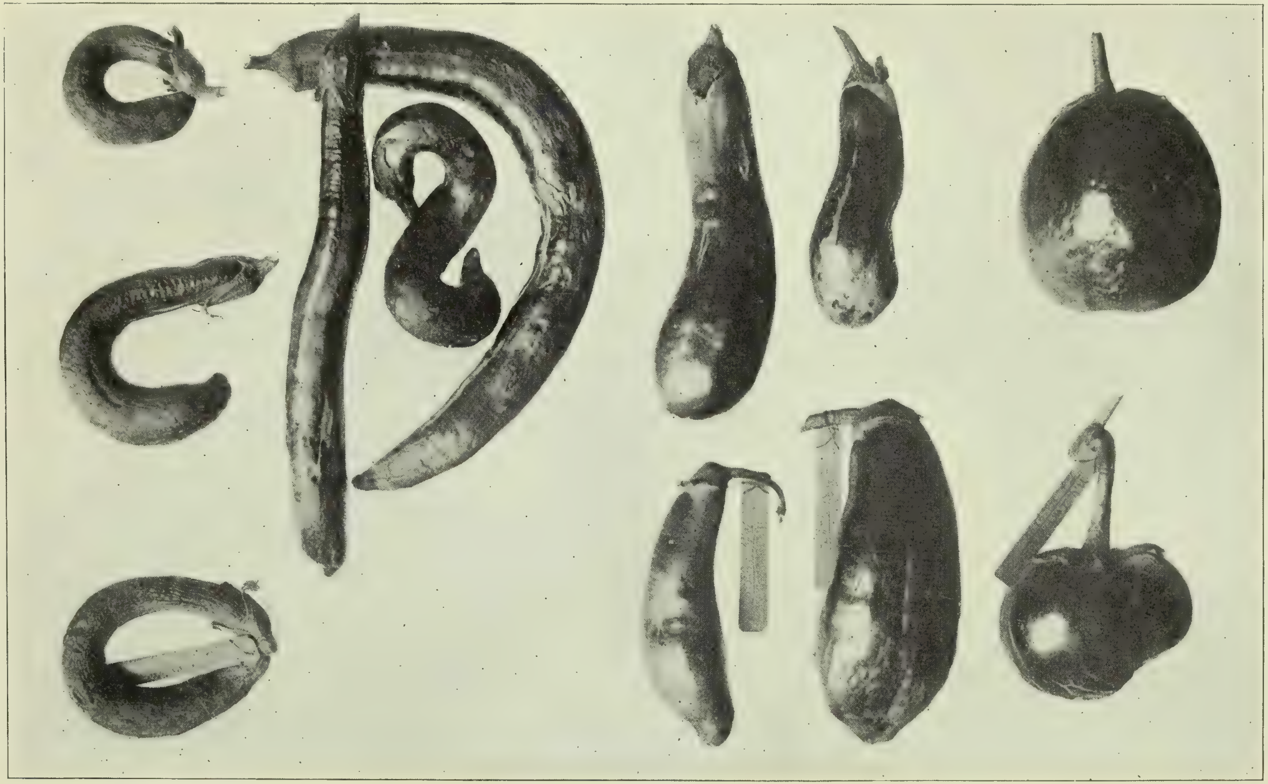


PLATE III.

Japanese Eggplants. Three varieties are shown in the upper portion of the engraving, and with fruits from pollinations with "N. Y. Improved" shown below with labels.

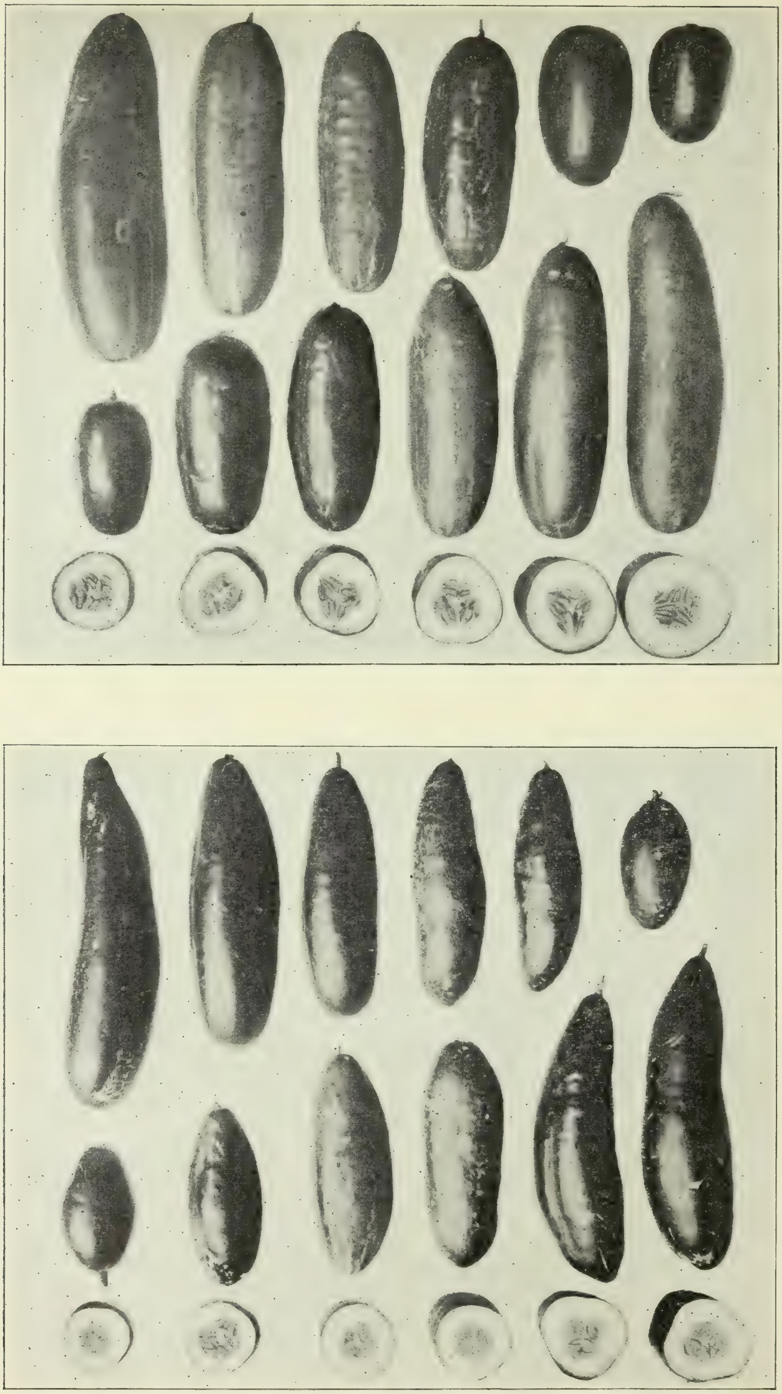


PLATE IV.

Cucumbers. Upper half shows a series of "White Spine" and "White Pearl" crosses. Lower half shows a corresponding set of "Telegraph" and "Zuaim" crosses.

white and purple here as in that case. In shape, however, there was a decided difference, for here both parents were of the round type and the crosses deviated but little from the form common to the two parents.

4. "Fordhook Improved" upon "Mammoth Pearl" gave a mixed lot of crosses, some of the fruits being purple, while others were white. The male parent does not differ essentially from the "New York Improved," and the mother plant is close to the "White Pearl." There is, therefore, in this cross a blending of the large, well-formed purple sort with a much smaller, more slender and white variety.

The one thing that deserves special mention in this connection was the remarkable vigor of the crossed plants and their great productiveness. They occupied a half plot, while adjoining them were standard commercial sorts, and the difference was remarkable. The crossed plants averaged fully twice the size of the others and kept in bloom up to the time of hard frosts—near the 1st of November.

Two years ago, when the cross between "Long Purple" and "New York Improved" were grown for the first time, the same observation was made and set down in the report for that year in the following words: "The plants of this cross have proved of remarkable vigor, so great, in fact, that it has been suggested that for this reason alone the cross is a great gain." The crossing of eggplants is not a difficult matter, the flowers in all their parts being of large size, and it is recommended that it be engaged in by growers of this truck plant for the added strength and consequent fruitfulness that it brings.

BREEDING OF CUCUMBERS.

Plot IV., Series I., was devoted to the crosses of the "White Spine" and "White Pearl" cucumbers that were obtained in 1899. Plate IV. (upper half) shows the range of variations in these crosses, the fruits being taken when nearly mature. It is seen that some of them are very short, not much longer than broad, while others are quite long. Some of those of medium size were comparatively smooth, and by selecting from these it is hoped to obtain a fruit that will be more desirable than either of the parents.

A corresponding set of fruits was selected from the plants (Plot III., Series III.) of the cross of "Telegraph" upon "Zuaim," secured in the greenhouse during the winter season. The two smallest

fruits are full-blooded "Zuaim" cucumbers, grown for the purpose of comparison. As stated in the last report (pages 389 and 390), this is an old variety that has long been grown commercially in Austria, the seed of which was secured by Mr. D. G. Fairchild, of the United States Department of Agriculture. With us the "Zuaim" produces short, plump fruits and in limited numbers. The "Telegraph," upon the other hand, is a popular indoor variety, the fruits of which are very long, comparatively seedless and with a consequent firmness of flesh. It was with the hope of developing these characteristics in field-grown cucumbers that the "Telegraph" was used as a pollenizer. By comparing the series of sections of six different fruits of this cross with the corresponding series for the "White Spine," "White Pearl" cross, it will be seen that there has been some loss of seediness and corresponding gain in the flesh. The effect of the male parent is shown in the tapering stem end of the crossed fruits. A glance at the two sets of fruits will make this very apparent. Should one center his vision upon third fruit from the left in each of the six rows the differences in mind will be quickly established. It is this grade of fruits that is reserved for seed.

The year was an exceedingly poor one for all crops of this class, and the yield was poor and the fruits not what might have been expected with all conditions favorable. Melons, for example, were an entire failure in many parts of the State.

CROSSING OF SQUASHES.

During 1903 the whole of Series 0 was in crossed corn, and, following the old-time practice of farmers in growing pumpkins with their corn, squash seeds were planted in some of the hills. Thus a small portion of Plot I. received seeds of "Long Island White Bush" squash and another part a few plants of "Mammoth Bush Summer Crookneck" were grown, while a third portion carried some vines of a novelty named "Delicious." A part of Plot II. had the "Golden Hubbard," in addition to the corn, while Plot III., in like manner, bore the old standard "Hubbard," and the remaining plot (IV.) had some vines of the "Boston Marrow."

During the season time was found for attempting some crosses. Thus, pollen was taken from both the summer varieties to pistillate flowers of each of the four late sorts, and the reverse was also true,

but in no instance was any fruit obtained as a result of the various attempts, fully twenty-five, between the summer and the late varieties. Otherwise were the results between the two bush varieties, and full-sized fruits were obtained with both the "Flat" and the "Crookneck" variety, as the mother parent and these specimens resembled in all respects the variety furnishing the pistillate flowers in the cross.

Among the late squashes crosses were secured only between the "Hubbard" upon the "Boston Marrow" and the "Delicious" upon the "Golden Hubbard." The "Hubbard," for example, always failed when attempts were made to breed other varieties upon it. In passing, it may be remarked that the wet weather that prevailed while the bags were upon the blossoms may have largely decreased the successes, for the young fruits (pistils) decayed rapidly when covered, and the setting of fruit was poor with flowers left in normal condition.

It is seen that there are four crosses secured—that is, the reciprocal ones with the two summer sorts, and the two which involve all the four late varieties, which will be enough for a supplemental crop in the plots of corn that it is planned to grow the coming year. The two varieties of summer squashes that have been crossed upon each other differ greatly in the form and color of their fruits, those of the "Long Island Bush" being white, disk-shaped, and, except for their scalloped sides, are comparatively smooth. There is very little difference in the general appearance of the fruits of different plants of this variety. The "Crookneck" squash produces long, yellow and somewhat bell-shaped fruits, and there is often a noticeable difference between the fruits of different plants; in some the smaller or "neck" end is much curved, and in others but slightly. Some may be thickly beset with wart-like outgrowths, while others are nearly smooth. As to size of fruits and productiveness, the two varieties did not seem to differ much; marketable fruits ranged in weight from one and a half to four pounds.

The foliage of the two sorts is much alike, except that that of the "Crookneck" is somewhat darker and the leaves of the "Long Island Bush" are slightly mottled. The leaves of both, unlike those of the winter sorts, are deeply lobed. The leaves are also smaller than those of the winter varieties.

The four varieties of winter squashes selected for crossing differ strikingly from each other in some respects. In color of foliage there seems to be very little, if any, contrast. The leaves of the

"Hubbard" are somewhat larger than those of the other three, and while many of the leaves of the "Boston Marrow" and "Golden Hubbard" are apt to be crinkled or fluted, those of the "Hubbard" and "Delicious" are plain.

In the cross of "Hubbard" upon "Boston Marrow" we have a union of two varieties having very different fruits; those of the "Hubbard" are dark green in color, while those of the "Boston Marrow" range from a light yellow to a darker reddish yellow. In form the "Hubbard" tapers gradually at both ends, while the "Boston Marrow" ends abruptly, tapering at the stem end only. At the Experiment Area the latter variety produced larger fruits than the "Hubbard."

The "Golden Hubbard" squashes may be a light yellow or a darker orange-yellow (different shades than appear in the "Boston marrow"), except at the outer tip, which is dark green. Though smaller than the "Hubbard" squashes, they are of nearly the same shape.

The recently-introduced "Delicious" variety has fruits of about the same shade of green as those of the "Hubbard," and of much the same form as those of the "Boston Marrow." In size, the few fruits obtained this season were fully as large as those of the "Golden Hubbard."

There was considerable difference in the number of plants of the different varieties and no record of number or weight of fruits was kept, but it is thought a like number of plants of "Golden Hubbard" yielded a greater number of fruits than any of the other winter sorts. By weight, however, the "Hubbard" may be more productive, since its fruits averaged a large size. The "Boston Marrow" would be given third place in this list, although its yield was fairly good. The "Delicious" made but a poor showing, since it commenced to fruit much later than the other sorts and matured only about half a dozen fruits.

In connection with the question of pollenation and crossing among squashes, it is well to look at the botanical side of the matter. The genus Cucurbita, to which the squashes belong, is made up of the following annual species under cultivation: (1) *Cucurbita Pepo* L.; (2) *C. moschata* Duch.; (3) *C. maxima* Duch. To the first belong the pumpkins which were grown by the American Indians in their fields of corn before this country was settled by Europeans, and may be native to the warmer portions of this continent. From this species

has come a group of gourds, like the "nest-egg," "orange," "mock-orange," "pear" and "Turk's turban," that are grown to some extent for ornament, and, being hard-shelled, serve as domestic utensils. These represent the *C. Pepo* var. *ovifera,* so named from the egg form above mentioned. A second variety includes the bush sorts of plants that run little or not at all, to which the name of *C. Pepo* var. *condensa* has been assigned, from its compact or condensed habit of growth. Under this variety are gathered the scallop and crookneck squashes and bush pumpkins, and furnish the many sorts of summer squashes.

The *Cucurbita moschata Duch.* are long, running like ordinary pumpkins and squashes, which Bailey* states is "possibly of East Asian origin." This is not grown with us to any extent, and furnishes, among others, the winter or Canada crookneck variety.

Under *Cucurbita maxima* Duch. are classed the forms that are most generally termed squashes, as illustrated by the "Hubbard" and "Marrow" types. The flesh of the fruit is orange, and in shape is not crooknecked.

These three species differ in nothing more strikingly than the stem to the fruit. In *C. Pepo* it is very hard and deeply grooved close to the fruit at maturity, while *C. moschata* has the stem also grooved, but much enlarged as it joins the fruit, while in *C. maxima* it is large, soft and is neither ridged or enlarged as it joins the fruit. The leaves of *C. Pepo* are much lobed and dull green, and in *C. moschata* they are rounded and grayish, while *C. maxima* has a kidney shape in evidence.

Bailey states that *C. Pepo* and *C. maxima* do not cross, neither do *C. maxima* and *C. moschata,* but *C. Pepo* and *C. moschata* have been bred together. Our successful pollenations have been, first, between varieties of *C. Pepo* and, secondly, between sorts of *C. maxima,* and all attempts to hybridize the two species have resulted in failures.

There is an opinion more or less current among truckers and others that melons, cucumbers and pumpkins will mix with each other, and this subject naturally comes up with the work that is given above. Many melons are poor in quality and suggest that they have been hybridized with pumpkins, squashes, cucumbers or other species of the same family. This conclusion as to origin, as determined by taste and possibly general shape of fruit, which varies greatly in many instances, is contrary

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* Cyclopedia of American Horticulture.

to the careful work of various experts. For example, Professor Naudin experimented many years with different species and found that they rarely hybridized, and then the results were usually sterile; Professor Bailey made numerous pollenations between our two common species of *Cucurbita,* and he states that "all our experiments show that *Cucurbita pepo* and *C. maxima* do not hybridize." A few years later Professor Pammel made extended attempts to produce hybrids, and from his work concludes:* "(1) that pumpkins (*Cucurbita pepo*) and squashes (*Cucurbita maxima*) will not hybridize; (2) that pumpkins and watermelons (*Citrullus vulgaris*) will not "mix," nor will squashes and melons "mix;" (3) cucumbers (*Cucumis sativus*), sugar and muskmelons (*Cucumis melo*) will not hybridize, nor will they "mix" with pumpkins; (4) the different forms of *Cucurbita maxima* will readily cross with each other—"Mammoth Chili," "Hubbard," "New Prolific Marrow," "American Turbin," &c.; (5) The forms of *Cucurbita pepo,* as the "Long Warted," "Nest Egg Gourd," "Vegetable Marrow," "New Golden Bush," "Bush Scalloped," "Italian Striped," "Perfect Gem," "Common Pumpkin" and "Sweet Sugar" will readily cross with each other.

When we find that two species of the same genus (*Cucurbita*) do not hybridize, it is scarcely to be expected that plants in different genera will "mix."

EXPERIMENTS WITH TOMATOES.

The crossed tomato stock the past summer was confined to the first three plots of Series II., and included about 200 plants. These were descendents of a few special selections from the first crop of crossed plants in 1900, and represent the fourth and, in a few instances, the fifth generation. A majority of the plants represented combinations of a few of the original numbers. Such combinations were made in the summer of 1901, when considerable crossing or breeding was done of the choicest representatives of the second generation.

A type of tomato has been developed from a combination of No. 144 upon No. 150 (144/150), the original parents of which came from the same red fruit that resulted from a cross of "Golden Sunrise" upon "Dwarf Champion" in 1899. The yields of these parents for 1900 are given for the season in the tables in the report for

* Results of Crossing Cucurbits, Bulletin 23, Iowa Experiment Station, 1893.

PLATE V.

Tomatoes The "Station Yellow" is shown in the center in three views, and foliage, with the male parent, "Golden Sunrise," upon the left, and the mother variety, "Dwarf Champion," upon the right.

that year. The two plants were remarkable for their good qualities, and breeding them together has resulted in a type of plant resembling the "Dwarf Champion," or orginal mother plant, but with a fruit that is yellow, like the male parent, or "Golden Sunrise."

Plate V. shows this new tomato, called "Station Yellow," in the middle row of the picture, while the male parent variety, the "Golden Sunrise," is upon the left, and the female parent, the "Dwarf Champion," is to the right of the cross. It should be said, in justice to all three sorts, that the specimens for the photographs were taken at the close of the season—about the middle of October—and when there was no opportunity to make any selection of the best fruits. The upper portion of the picture shows the general contour of the tomatoes looking from the blossom end, while the corresponding view upon the stem end is shown in the three fruits in the middle row below, which are given interior views of the same three varieties of fruits. The first and second row from the left are yellow fruits of nearly the same character, the "Station Yellow" being somewhat more firm or "solid," and therefore less polygonal or "angled" in general outline. The latter variety has a tendency to develop a blush upon the maturing fruit, perhaps due to the cross with the red "Dwarf Champion." The character that makes the variety distinct is in the vine, which is of the upright habit of its red mother, and does not have the prostrate or sprawling method of growth of the "Golden Sunrise." The nature of the foliage of the three varieties is indicated by the spray of each that are shown in the upper part of the plate. To those who know the bushy habit of the "Dwarf Champion," with its thickly-set leaves upon a plant of under size, and the nearly opposite characteristics of the "Golden Sunrise," will expect what is obtained in the cross, namely, a larger plant than that of the female parent, and one with something of the great vigor of the male parent. To say that it is a yellow "Dwarf Champion" is not telling the whole truth, because the differences are more than color of fruit. The plants and the fruit are both somewhat larger than the "Dwarf Champion," and the foliage is not so much infolded or "curled," or "potato-like," as some are pleased to call it.

On account of the tendency to blush that is developed in the "Station Yellow," it has been selected as a sort with which to breed further with red varieties, in the hope of establishing a kind with the blush fully developed.

No. 177 was originally from a red fruit resulting from a cross of "Golden Sunrise" upon "Dwarf Champion" in 1899. Concerning the plant the following is quoted from the Report for 1900 (page 438): The plant (No. 177) "was a giant in stems and foliage, standing high above the surrounding plants. Its leaves combined the characteristics of the two parents, and the flowers were of unusually large size. The most remarkable point was the smallness of the fruits, being about an inch in diameter and two ounces or less in weight, with seeds ranging from none to six for each fruit. There were only twenty-seven fruits produced upon this plant, four of which were green at the close of the season. The cross expressed by the numbers 177 upon 177 (177/177) indicates a union of two plants from the same original parents, some of which were made.

The most progress toward a seedless fruit seems to have been made in case of a number of plants developed from the No. 177. Seeds of third-generation fruits of this number were sown in the greenhouse the past winter, and some of the seedlings were remarkable owing to their having three, and in one instance, four cotyledons. From these seedlings a few small and almost seedless fruits were obtained and from these came, for a late setting, the plants in rows 5 to 10 in Plot III. Several of these have produced more and larger fruits than their parent plants and bore a very limited number of seeds. Specimens of these fruits are shown in Plate VI. The number of seeds in each fruit ranged from five to fifty, while those of ordinary tomatoes is among the hundreds.

Tests of Varieties of Tomatoes.

A portion of Plot IV., Series V., was given to a test of several varieties of tomatoes, some of them being classed as "Novelties." To the test was added the "Dwarf Champion" and "Golden Sunrise" for sake of comparison. The table below shows some of the results:

Name of Variety.	Total No. Ripe Fruits.	Total No. Green Fruits.	Grand Total.	Average per Plant.	Rank in Size.
"Dwarf Champion"	103	20	123	24	8
"Golden Sunrise"	232	36	268	53	5
"Freedom"	374	47	421	84	6
"Crimson Cushion"	253	31	284	56	2
"Chalk's Early"	312	19	331	66	7
"Ponderosa"	209	38	247	49	1
"Marvel"	431	31	462	52	3
"Magmus"	428	62	490	98	4
"Thorburn's Earliest"	528	60	588	117	9

PLATE VI.

"Seedless" Tomatoes The group of fruits upon the left are from cuttings of No. 177 grown in the field. The fruits upon the right are from various seedlings of No. 177.

It is seen that fruits of the "Thorburn Earliest" outnumbered those of any other variety, but they were of the smallest size. The "Magus" stood next in fruit record, and the tomatoes ranked fourth in size, so that this variety gave a greater yield in pounds of fruit than any other sort. This variety has a somewhat upright vine, "potato-leaved," some would say, and resembled much the "Dwarf Champion," but is a much larger plant. The largest tomatoes were produced by "Ponderosa," but it was only second in number of fruits per plant. The "Dwarf Champion" variety did poorly in this test, yielding only twenty-four fruits per plant, and these of the usual medium size.

EXPERIMENTS WITH BEANS.

The first three belts of Plot I., Series V., were planted June 1st with alternating rows of "Green Flageolet" and "Saddle-back Wax" beans; and on June 27th the same varieties were planted in belts 4, 5 and 6. While the stand of the "Saddle-back Wax" sort was good, there were scarcely any plants of the "Green Flageolet" obtained from either planting. With the few that appeared, about a dozen attempts were made to cross-fertilize "Saddle-back Wax," only one of which was successful. An average-sized "Wax" pod containing three black beans was secured.

Considerable leaf and pod-spot (*Colletotrichum*) developed upon Experiment Area beans this season. The product of a late fall planting "Saddle-back" and "Bountiful" varieties was much more severely infested by disease than earlier crop.

Experiments with Dwarf Lima Beans.

Lima beans have been grown upon the Experiment Area since 1896, when they were employed to test various fungicides for the diseases of this crop. The following season, Plot IV., Series III., was planted to three varieties of dwarf lima beans, namely, "Burpee," "Dreer" and "Henderson." For this crop the "Burpee" far exceeded the other varieties in marketable pods for the same area—*i. e.,* producing 99 pounds to 45 for the "Dreer" and 39 for "Henderson." By shelling the pods of each variety the ration of productiveness of seeds was determined to be as 20, 9 and 8, respectively, for the three sorts. In

time of maturing there is no difference between "Burpee" and "Dreer," while the "Henderson" gave pickings at a much earlier date and has a long period of fruiting. At that time a full description of each variety was prepared and published later in the report for the year. The "Burpee" and "Dreer" are closely related and belong to a distinct variety of the species, with the botanical name in full as follows: *Phaseolus lunatus* var. *macrocarpus* Benth.—that is, the large-fruited lima—while the "Henderson" belongs to the species, but not the variety, and botanically is simply *Phaseolus lunatus* L.

In order to show something of the history of the three sorts and how recently they have been developed, the following is given as gathered from a bulletin* by Professor Bailey. The "Burpee" originated with Mr. Asa Palmer, of Kennet Square, Pa., and was introduced to the public by Mr. Burpee in 1890 as the "Burpee Bush Lima." In 1883 Mr. Palmer found one plant of his pole lima beans had rerooted after being eaten by cut-worms. It remained dwarfed and produced a few seeds, and from these seeds the variety was developed. The "Dreer" originated from the "Challenger" pole bean by selection of dwarf forms which a Mr. J. W. Kumerle found growing in his field of beans at Newark, New Jersey, and was introduced in 1889 by both Thorburn and Dreer. It is of the same blood as the "Burpee." Of the "Henderson," Professor Bailey writes: "It was picked up twenty (thirty now) or more years ago by a negro who found it growing along a roadside in Virginia. It was afterwards grown in various gardens, and about 1885 it fell into the hands of a seedsman in Richmond. Henderson purchased the stock of it in 1887, grew it in 1888 and offered it to the general public in 1889."

Thus all varieties were introduced within two years.

In 1898 the experiments with lima beans were limited to the two sorts, "Burpee" and "Henderson," and while the study of the diseases and their treatment were leading points in the work, a comparison of the two varieties was not overlooked. It was found that the "Henderson" is much less subject to the various bean diseases than the "Burpee." The former will bear a half more plants in a row, owing to their smaller size, and then weigh but a trifle more than two-thirds as many of the "Burpee." The yield of fruit is, however, under such conditions much in favor of the "Henderson," and the latter furnishes pickings much earlier than the "Burpee" and fully as late in the season.

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*The Dwarf Lima Beans, Bulletin 87, N. Y. Cornell Experiment Station, 1895.

During 1899 belts 1, 2 and 3 of Plot IV., Series III., were in lima beans for the fourth successive crop, and with the two varieties of the previous season grown as before in alternate double rows throughout the half plot. The sprayings were eleven in number, extending from June 2d to September 12th, and there was very little disease, the "Henderson" pods being all in healthy condition. The records show that for 1899 the yield of marketable pods, in pounds, was greater for the "Burpee" than for the "Henderson," thus making the average for the past two years about equal.

In 1900 two adjoining belts (1 and 2, Plot III., Series 0) were planted with seeds from plants suspected of being possible crosses between "Burpee" and "Henderson" while standing in the adjoining rows of the crop of the previous year. In the "Burpee" belt there were twenty plants that were different from the rest, and appeared to be crosses between the two above-named varieties. Many of these plants were much smaller than the "Burpee" and near the size of the "Henderson," and had the darker and more glossy foliage of the latter sort. Some of them, however, were nearly as large as the "Burpee," and showed but little of the characteristics of the "Henderson."

A record was made in the Annual Report (1900) of the general type of the plant—that is, whether nearer one or the other plant—and a number of green and ripe pods and a plate showed the form and relative size of the pods and seeds.

In 1901 seeds of all the twenty plants above mentioned were planted, and all produced from one to seventy-two plants, excepting two (Nos. 1 and 16), which failed. In vigor the sets of plants were generally satisfactory. "There were many individual differences from the time the seedlings unfolded their first true leaves, and the plot showed those evidences of a mingled blood that plant-breeders find so difficult to set down in words." Some rows were more uniform than others, favoring one parent or the other, as the case might be. All the plants of the plot remained true to the dwarfed type excepting seven, and those were given poles and climbed, with one exception, with the characteristics of genuine pole beans. Opportunity came for testing the quality of some of the crosses, and it was found to compare favorably with that of the "Burpee" and superior to that of the "Henderson." There was a variation in quality, as there was in the character of the plant and seed, among the several sets.

In 1902 selected seeds from the several sets of crossed plants were planted and a crop grown and harvested for each. There was little to be added to the observations upon these sets of beans of the previous year.

From this large stock of seeds the following numbers, 2, 4, 5, 6, 15, 18, 19 and 20, were selected as being the most promising.

Crossed Lima Beans in 1903.

Plants representing a fourth generation of the crosses between "Henderson" and Burpee" drawf limas were grown the present season in the first two plots of Series I. The seed was planted in Plot I. June 1st, and not until June 22d in Plot II. The twenty-four rows in the first plot and the first eight in the second were from seed of dwarf limas, selected in 1902 from the most desirable of the crossed plants, and eight such selections were used the present season—a different lot of seed being used for each four rows.

A medium stand of plants was obtained from this "Bush" seed, and of the twenty-four rows in the first plot, six were wholly free from climbing or trailing plants, and six others contained only a few specimens that were somewhat inclined to run towards the end of the season. All the remaining twelve rows contained a large percentage of climbing plants. None but dwarf sorts appeared in four of the first eight rows of Plot II., and in the other four there were six pole limas.

The remaining twelve rows in Plot II, were from seed of crossed plants that had required poles the preceding season. Each three rows represented a different lot of seed.

Considerable variation was noted in the different rows of crossed limas the present season. In case of the dwarf sorts, some rows were earlier than others, and some were especially fruitful. The yield, as a rule, seemed equal to that of an average "Henderson" plant. In certain rows the pods were much like those of the "Henderson" type, while in others they were noticeably larger, although smaller than those of the "Burpee" variety.

A like variation in fruitfulness and size of pods occurred among the crossed pole limas. The pods of these, in most cases, were larger than those of the "Henderson" variety, and some were nearly equal to those of the "Burpee."

The limas were not seriously harmed by disease in 1903. The pods were lightly infested by the pod blight, and mildew became quite conspicuous, but not until late in October. No fungicides were applied.

Varietal Study of Lima Beans.

In connection with the work in crossing and breeding lima beans a small space—a row thirty feet long—was given to a test of each of the following varieties, with the results as shown in the table below:

Kind.	Number of plants.	Number green pods.	Number dry pods.	Total pods.
"Henderson"	36	664	205	869
"Burpee"	46	165	.....	165
"Thorburn"	38	15	.....	15
"Dreer"	44	225	.....	225
"Willow-leaf"	47	709	181	890

In this set there are two groups of dwarf limas represented, the first and last named being of small stature, dark-green foliage and with the pods and seeds comparatively small. The other three varieties are closely related, with large plants and pods and seeds. Plate I. of the report for 1901 shows the seeds of "Henderson" at 1 and 4, and of the "Burpee" at 3 and 6, both in the green and ripe condition.

It is seen that the "Henderson" and "Willow-leaf" were far superior in productiveness to the other three sorts. This may in part be due to the season, which was very dry in May, so that the plants had a late start. This was followed by an unusually wet June and August. A more even rainfall throughout the growing season might have given quite different results.

The only disease that seemed to make any headway among these trial beans was the mildew, and for its development the wet August seemed particularly favorable. It was noticed from time to time upon the three larger sorts, and doubtless had somewhat to do with their low yield, but upon the smaller podded sorts it was not in evidence.

All of the five varieties were remarkably uniform, with the exception of the "Willow-leaf," among which were fourteen plants that were somewhat larger than the others, and with the leaves broader than the type. The pods of these plants were somewhat above the average in size and in number to each plant. The seeds of these have been saved for further testing as to fixedness of character, productiveness and market value.

Plate VII. shows small heaps (thirty seeds) of each of the five varieties, as named below their respective seeds. The lower row shows corresponding heaps of the six bush sorts of the crossed limas that were grown the present season.

It is not easy to make a comparison of these several sorts, because they have no one point that is a unit of measurement for all. However, the number of pods per plant has been determined, and, avoiding all fractions, is as follows:

"Henderson"	24	"Burp.-Hend., No. 2"	8
"Burpee"	4	"Burp.-Hend., No. 4"	11
"Thorburn"	5	"Burp.-Hend., No. 5"	9
"Dreer"	5	"Burp.-Hend., No. 6"	8
"Willow-leaf"	19	"Burp.-Hend., No. 18"	10
		"Burp.-Hend., No. 19"	10

The "Henderson" and "Willow-leaf" lead in number of pods, but they are smaller than those of the other sorts.

EXPERIMENTS WITH FUNGICIDES.

The systematic use of fungicides for the current year has been confined to spraying in the greenhouse, a report of which has appeared in the bulletin* issued during the summer. In the field spraying has only been done to preserve the crop plants from the ravages of insects. The tests with fungicides were omitted that the effect of clean culture might be noticed for the year. As stated elsewhere, the eggplants were comparatively free from disease until late in the season, when the moist conditions favored the rapid growth of the fruit rot. In like manner the tomato plants suffered but little until in September, when the leaf-spot became evident, and during the following month the foliage was considerably affected. The plants upon the Experiment Area were not blighted to the extent seen elsewhere, and this seems due in part to the regular practice of keeping the vines clean of diseased parts during the growing season and burning all vines and rubbish on the Experiment Ground whenever the crop is removed.

* No. 167. Some of the Newer Fungicides. June 29th, 1903.

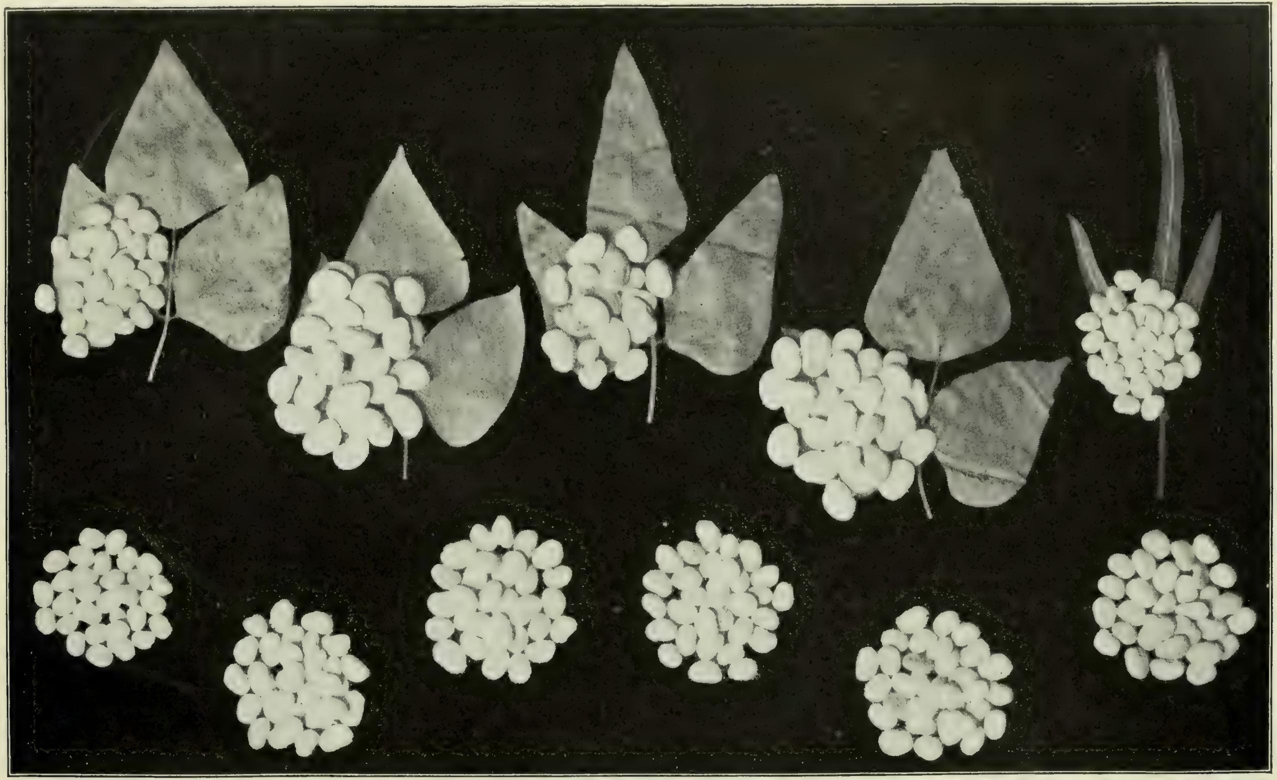

PLATE VII.

Dwarf Lima Beans. Piles of twenty-five seeds of five standard sorts in the upper row, and of six of the crosses in the lower row.

EXPERIMENTS IN SHADING.

But little has been done the present season in the matter of shading. While previous experiments have shown that an artificial cover may be of considerable service to certain crops, this important feature of the experiment work has been set aside owing to pressure of other things.

The use of lath-shading* (with spaces between the lath equally the width of the lath—that is, half-shading) has proved very effective with nasturtiums the present season. These plants often have their foliage burned by the hot sun, and a small amount of shading will prevent this. In case of the canary-bird nasturtium (*Tropæolum Canariense*), the lath-shade made all the difference between plants with burned leaves and no flowers and those with sound foliage and abundance of bloom. The lath frames were placed high up above the plants, so that they did not interfere with the climbing of the plants or the care of the ground around them.

EXPERIMENTS WITH JAPANESE REDBUD.

In 1896 two dozen plants of the Japanese redbud (*Cercis Japonica*) were set out in a single row in a portion of the Experiment Area devoted to ornamental plants. In a visit to the nursery from which the plants were afterward obtained it was determined that the cercis was badly attacked by a leaf-spot fungus (*Cercospora cercidicola* E.) which produced large, circular, brown spots in the handsome leaves, which afterward died and fell to the ground. In September of the first season of the experiment after faithful spraying of certain plants with fungicides, a visit was made to the nursery from which the plants had been obtained. At that time the redbuds, by the thousands, in the nursery rows, were nearly all leafless from the attack of the leaf-spot. The difference between the plants and those taken to the Experiment Grounds, many miles away, was very striking. This is a forceful illustration of the healthfulness that may follow the removal of plants from a locality where its kind has been grown for years in large numbers and a disease has developed to a serious extent. As the plants experimented upon were all comparatively

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*The method of making lath frames is described in the annual report for 1897, page 344.

free from the leaf-spot, there was no marked difference between the sprayed and the unsprayed specimens.

The experiments with spraying mixtures was continued in 1897, and the record shows that "but very little blight upon the foliage during the whole season, and no marked effect can be recorded for the fungicides." The spraying continued through 1898, "but without results, owing to the absence of the redbud blight." All this time the plants had showed marked differences in hardiness. The record for 1899 contains the following: "Two or three of the trees were much injured during the last winter. No blight developed during the summer, but several were somewhat injured by sun scald."

This tenderness to the extremes of winter's frost and summer's sun has been so great that at the present time the number of the healthy plants is limited to three, while fully half have died and several are unshapely and worthless as ornamental dwarf trees. One of the three that has proved hardy is an especially fine specimen, and nearly perfection in its shape and luxuriant foliage. This plant flowers profusely in early spring and fruits abundantly in autumn. Seeds are gathered from this, and it is hoped that, by careful selection from its seedlings, a hardiness may be obtained, after a few generations, that will place this redbud among our most attractive lawn trees.

EXPERIMENTS WITH LAWN GRASSES.

The nine plots seeded to grasses, as shown in the following table, have been kept cut with the lawn-mower during each season since 1896. The condition, or stand, of each kind of grass is given in percentage, following the plot number and kind of seed sown:

Plot.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.
1. Meadow Fescue (*Festuca pratensis* Huds.)....	90	50	40	45	55	60	60	80
2. Fine-leaved Fescue (*Festuca tenuifolia* Sib.)..	5	50	40	40	40	45	45	40
3. Sheep's Fescue (*Festuca ovina* L.)..............	10	50	40	40	30	25	40	40
4. Rhode Island Bent (*Agrostis canina* L.)......	80	80	90	90	90	95	95	95
5. Wood Meadow (*Poa nemoralis* L.)............	60	65	70	85	80	85	90	85
6. Kentucky Blue (*Poa pratensis* L).............	50	65	90	90	85	85	80	80
7. Rough Meadow (*Poa trivalis* L.)................	90	65	70	70	45	70	60	50
8. Redtop (*Agrostis alba vulgaris* With.).........	100	90	70	60	25	25	20	50
9. Perennial Rye (*Lolium perenne* L.)...........	100	85	70	40	20	15	15	40

The "Rhode Island Bent" has held the first place for four years, and gives a very satisfactory turf for a lawn. The texture is fine, but, in dry spells, it sometimes turns brown. In the "Wood Meadow" the makers of fine lawns will find a valuable grass; the turf of this has improved gradually from the start, eight years ago. The "Kentucky Blue" is another grass that has proved very satisfactory and secured a high rating since 1898. Aside from "Redtop" and "Perennial Rye," which have been poor, the other four species have maintained a middle place in the list of varying percentages of merit.

In these plots the weeds have been permitted to grow, the chief of which during the whole season is the dandelion, and in autumn a crab grass fills all vacancies, and is much in evidence in some of the plots.

At one time during the season the plots were left uncut for a time to permit an estimate being made of the mixing that had gone on among the grasses of the various plots. It was thus determined that the "Kentucky Blue Grass" had spread so much that it made up fully 50 per cent. of the first three plots and Plot 9, and was even more largely represented in Plots 5, 7 and 8. It had not made any headway in Plot 4 where the "Rhode Island Bent" held nearly full sway. A little of the Orchard Grass (*Dactylis glomerata* L.) had worked into Plots 1 and 2.

FRINGED PHLOXES.

Phloxes, and particularly *Phlox Drummondii* Hook., have received attention for the past three years, and several species are now represented in the Experiment Area. The large genus Phlox, of seventy species, is so named from the Greek for *flame* on account of the bright red color of many of the flowers. There are four species in the State, one of which, the "Moss Pink" (*Phlox subulata* L.), is the early bloomer that covers many otherwise nearly bare hillsides with a pink mantle and is among the first showy flowers of the season. In the south and west the representatives are much more numerous, as in Alabama* there are eleven species.

The species are herbs and generally perennial, with *P. Drummondii* an annual and a striking exception to the rule. It is of this species that the following is concerned. The Drummond Phlox is a low, erect and much-branching plant, with long leaves, more or less clasping the

* Plant Life of Alabama, Dr. Charles Mohr, 1901, pages 684–686.

stem by the broad base. The flowers are many, in flat-topped clusters, and under cultivation has run into a great variety of colors, from white to a very dark red.

Mr. Drummond, a maker of large botanical collections in the Southern States, collected the seeds in Texas and sent them to England in 1835. The species was described by W. J. Hooker in the Botanical Magazine, along with a picture of the same, and all under the name of the American collector.

Within the space of sixty-eight years the Drummond Phlox has become one of the favorite garden ornamental plants, and Bailey* writes: It "is of the easiest culture. This fact, together with the profusion and long seasons of its bloom, is an important reason for its popularity."

This phlox is a favorite in Europe, and Robinson† writes: "Nothing can excel its beauty and usefulness either as a border plant or for furnishing cut flowers. Its colors are varied and brilliant, and are not injured by bad weather like those of many other flowers. The wonder is that it is not more generally and extensively grown in gardens. It may be used in a variety of ways apart from border decoration. Beds of standard roses carpeted with it are highly effective, and the fact that the plant does not in any way touch the growth and well-being of the standard roses, the naked stems of which they both hide and ornament, should in itself be a sufficient inducement to plant this phlox especially for that purpose. It is also a very suitable plant for the embellishment of rustic vases and boxes, but it is when grown in masses that its beauty and diversity of color is seen to the best advantage."

It strikes freely from cuttings in autumn, and may thus give early flowers in abundance indoors for winter decoration.

With us this phlox is half hardy, and many seedlings from self-sown seed have withstood the winter in the open field, where there was no semblance of protection. During the coming winter a covering of dry cornstalks from the plots bearing sweet corn will be used over a portion of the area devoted to phloxes, and where an abundance of volunteer seedlings have established themselves since the last hoeing.

In 1901 the variety known under the trade name of *Phlox Drummondii* var. *cuspidata* was grown for purposes of crossing, and some

* Cyclopedia of American Horticulture.

† The English Flower Garden, 1889, page 601.

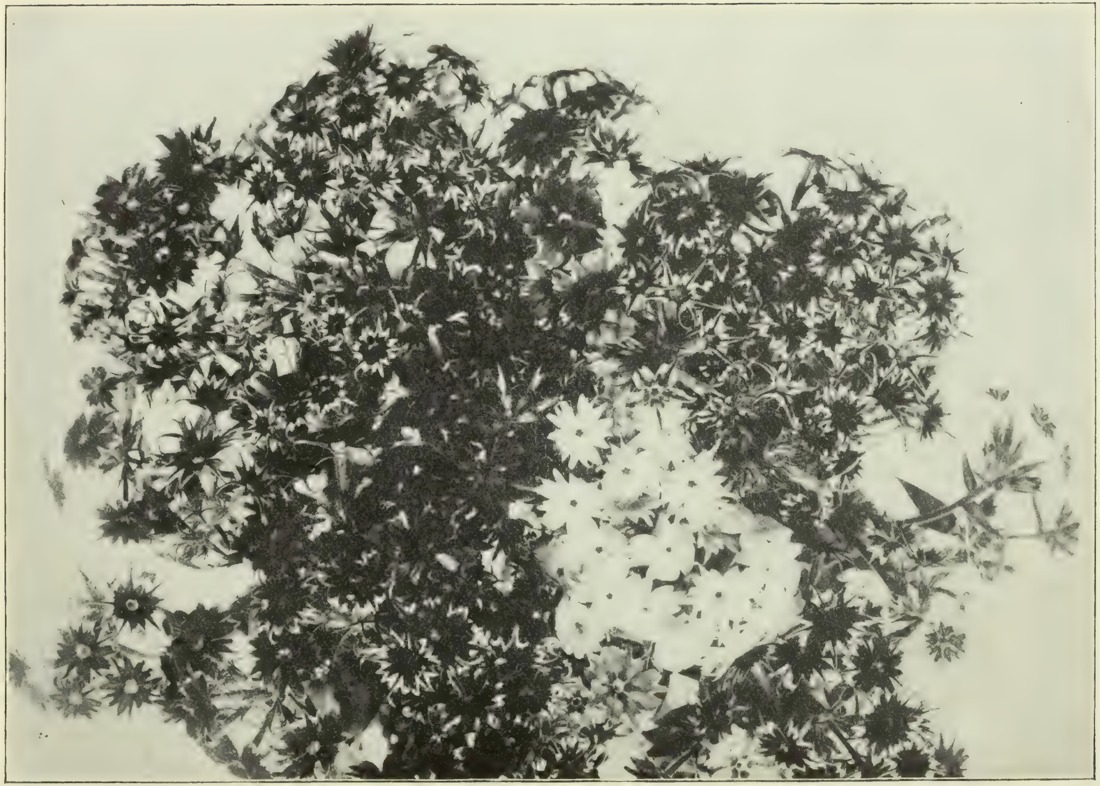

PLATE VIII.

Fringed Phloxes. A view, looking from above, of a bouquet of Drummond Phlox, showing various fringed and starry forms of flowers.

of the results were shown in Plate VI. of the report for last year. A very much larger number of variations have appeared the present season, some of which are particularly rich in both outline and coloration. Instead of the long, slender, single tip to each petal, as shown in the variety known among phlox growers as the "Quedlinberg or Star phlox," these often have a finely cut margin that is suggestive of the celebrated fringed gentian. One of the variations has been a pure white, with the delicate margin above mentioned. It has not yet been demonstrated that these types can be fixed by isolation of the plants so that fertilization within its own variation will be secured. Single plants may be multiplied by cuttings, and with care and time it is hoped that certain of the more desirable of the fringed types may become reasonably stable.

Plate VIII. shows some of the forms of the fringed phloxes as grouped loosely in a bouquet, the photograph having been taken from above. Near the center is a spray of pure white, and the effect is that of some of the mort attractive "Starworts" (*Stellaria*), "Starry Campion" (*Silene*) and other members of the pink family. Above and to the left of these are some with a rich, solid maroon, and because of their dark color they are nearly lost from sight in the picture. Others nearby have a dark center and a light border, and by this means the starry outline is well shown. A plain engraving cannot more than barely suggest the effects of these clusters of blossoms. There are fifteen or more distinct types, between which there is a decided difference as to form and color.

DATURA HYBRIDS.

Datura is a small genus, of about twelve species, native to the warmer portions of the globe. In our State there are two kinds, and these grow as weeds in rich, moist soil, under common names, as "Stramonium," "Jamestown," or "Jimson Weed," and "Thorn-apple." In this locality the two species *Datura Stramonium* L. and *Datura Tatula* L. are often in nearly equal numbers, and this, together with the fact that the chief difference is in the color of the stem, leaf-stalk and flowers, led to a testing of the seeds of some of these plants. Ripening, but still unopened, pods were gathered last autumn of *D. Tatula,* quickly recognized by the prevailing purple in stem, leaf and flower, and of *D. Stramonium,* which has white flowers and the

other parts of a uniform green. As a result of these sowings it was ascertained that, in some instances, as high as fifteen per cent. of the seedlings were of the species other than the one bearing the pod that produced the seeds.

This led to a further study of these two species, and while in the greenhouse the large, tubular flowers were easily, and generally, self-pollenized—the anthers maturing and discharging their contents before the corolla had opened—it was found that the two species crossed artifically with ease.

Early the past spring, in the Station greenhouse, reciprocal pollenations were made between *Datura Tatula* L. and *Datura Stramonium* L. and well-developed seed obtained. Both species were readily fertilized with the ornamental sort, *Datura meteloides* DC., but several attempts to fertilize *D. meteloides* with the other two failed.

About forty plants representing *Datura Stramonium,* fertilized by *Datura Tatula,* and six of which *Datura Tatula* was the pistillate parent, were started in the Station greenhouse and transplanted to the Experiment Area (Plot IV., Series II.) July 11th. More of the crossed seeds were sown in the same plot July 14th. From those of *D. Stramonium* upon *D. Tatula* eighteen plants were obtained, and over seventy of *D. Tatula* upon *D. Stramonium.*

Those who are familiar with the two parent species can observe a difference in habit in these hybrids, but the untrained eye would not be likely to detect anything to separate them from the purple species (*D. Tatula*). In other words, it does not matter in what way the union took place, whether *D. Tatula* upon *D. Stramonium* or the reverse, the offspring have all taken the purple color of the *D. Tatula* parent, and none of them retain the green stems and leaves and white blossoms of the *D. Stramonium.*

The crossing needs to be more extensive before any conclusions as to the results obtained can be safely drawn. It would seem that, were it not for the very general self-fertilization prevalent in these two species, they would soon be blended into one hybrid at the loss of the green *D. Stramonium.*

These large, "heavy-scented" flowers are not apparently favorites with any of our insects, whatever may be the facts in Asia, the probable home of *D. Stramonium,* and in tropical America, where *D. Tatula* is reported as being native.

It remains to see what the second generation of the hybrids may be,

for then it may be found that the green form is restored. A further study of the species may reveal before-undetected characteristics that may assist in a rational study of the hybrids.

Datura Meteloides DC.

At the same time that the above experiments were in progress hybridizing was under way with *D. Stramonium* and *D. meteloides.* This latter is one of the daturas native of New Mexico that is cultivated as an ornamental plant, the flowers being six inches or more long, tubular and white or pale violet, while the foliage has a delicately soft velvety appearance due to a fine coating of hairs. The stems and leaf stalks are a pale purple, and the white flowers show a tinge of the same color. The species represents a division of the genus that is distinct from the one to which *D. Tatula* and *D. Stramonium* belong.

Here it was found that the pollen is shed some time before the tube of the corolla develops into a bell, and it was necessary to remove the stamens several days before the time of blooming. In some instances success attended the application of the pollen of *D. meteloides* to the stigma of *D. Stramonium,* but all attempts to fertilize *D. meteloides* with the other two failed. The style of *D. meteloides* is fully twice the length of that of *D. Stramonium,* and this may account for the failure of pollen of the latter when applied to the stigma of *D. meteloides.*

Two pods fairly well supplied with seeds resulted from the *D. meteloides* upon *D. Stramonium,* and several seedlings were grown to fruitage in the open field during the past season. One set of these plants, all without much variation, have the green color of the *D. Stramonium,* while the seedlings from the other pod all have a uniform purple color that is even more intense than the parent *D. meteloides.* These hybrids as a whole were of the same general type as those between *D. Tatula* and *D. Stramonium* growing nearby. All seeds from *D. Tatula* fertilized with *D. meteloides* failed to germinate.

In a portion of Plot II., Series V., more crossing of *D. meteloides* upon *Stramonium* and *D. Tatula* was accomplished, and many attempts were made to work *D. Stramonium* and *D. Tatula* upon *D. meteloides,* but without success. One flower of *Datura fastuosa* L. (*D. cornucopia*) pollenized with *D. meteloides* produced a seed-bearing capsule.

EXPERIMENTS WITH WEEDS.

The weed belt has been continued for seven years without interference in any way—that is, plants have spread by roots, seeds have ripened and fallen, germinated and grown as they might be able in the fierce struggle with other kinds. It is needless to state that the ground has been occupied, and so to say two or more crops of plants have been made during the season, for some weeds are early in coming to the front and others delay until near the close of the season.

The following is the list of fourteen species that have been the most prominent during the year, arrayed in the order of their aggressiveness, the worst appearing at the head of the list and the least objectionable at the foot. Those weeds that were in the list for previous years, with their rank, are given in the table. Thus it is seen that in 1897 only five of the present list were then much in evidence, and, for example, the wild carrot was then twelfth on the list, while now it is second in rank.

	1897.	1898.	1899.	1900.	1901.	1902.	1903.
Rumex acetosella L. Sorrel	....	7	4	3	1	1	1
Dau·us Carota L. Wild carrot	12	......	....	4	5	2	2
Bromus racemosus L. Broom grass	....	....	....	....	2	3	3
Mililotus alba Lam. Sweet clover	....	....	....	12	10	10	4
Chrysanthemum Leucanthemum L. Ox-eye daisy	....	....	....	9	6	6	5
Polygonum Pennsylvanicum L. Smartweed	6	3	2	2	4	4	6
Aster paniculatus Lam (?) Aster	....	....	....	....	....	13	7
Convoloulus arvensis L. Bindweed	....	....	....	....	9	9	8
Taraxacum Taraxccum L. Dandelion	....	....	9	5	5	8	9
Silene noctiflora L. Catchfly	9	13	14	7	7	7	10
Abutilon Abutilon L. Velvetleaf	7	2	6	6	3	5	11
Oxalis stricta L. Oxalis	....	....	....	8	11	11	12
Ambrosia artemisiæfolia L. Ragweed	3	5	1	1	14	12	13
Rudbeckta hirta L. Yellow daisy	....	....	....	....	13	14	14

Other conspicuous species of weeds were:

Plantago Rugelii L.	Plantain.
Barbarea Barbarea (L.)	Yellow rocket.
Chenopodium album L.	Lamb's quarters.
Rumex crispus L.	Dock.
Arctium Lappa L.	Burdock.
Panicum sanguinale L.	Crab grass.
Aster sp.	Aster.
Hibiscus Trionum L.	Hibiscus.
Polygonum Convolvulus L.	Bindwood.
Acalypha Virginica L.	Mercury.
Ixophorus glaucus (L.)	Fox-tail.
Amarantus retroflexus L.	Pigwood.
Tragapogon pratensis L.	Salsify.
Tragapogon porrifolius L.	Salsify.

Various clovers (*Trifolium ripens, T. hybridium, T. pratense*) and the seedling grape and cherry still hold on against the weeds.

Chickweed (*Alsine media* L.) and low spear grass (*Poa annua* L.) were unusually abundant upon the Experiment Area this season.

Plantago media L. was observed upon the College Campus, and seems to be new to the State.

Galensoga.

The genus Galensoga is a small one, the members of which are natives of warm, temperate and tropical America. Heller* lists two species and one variety, and Mohr † mentions but one, which is *Galensoga parviflora* Car., the same as the one that is in New Jersey, and of it he observes: "Becoming a troublesome weed."

The species are all annuals, and in some respects resemble the stick seeds (Bidens), but without the hooked or barbed seed-coats. They are likewise close akin to the fleabanes (Erigeron) and many other members of the great composite family of which the thistles and sunflowers are familiar representatives. The galensogas are in bad company, for the family to which it belongs is one abounding in weeds.

The species, specimens of which have been sent in for name and methods for eradication from time to time, is a rapid grower and a quite leafy plant, as the engraving (Plate IX., Fig. 1) well shows. It is especially fond of a rich soil and a fair amount of shade, these

* Catalogue of North American Plants, North of Mexico, 1900.
† Plant Life of Alabama, 1901.

facts making the galensoga partial to the dooryard and any flower-bed that is neglected for a comparatively short time.

It is, as before stated, an annual, and needs to come from seed each season. With this in mind it is evident that, by keeping the intruder from going to seed, the trouble will be lessened. The writer has sometimes seen a gardener keeping the galensoga faithfully out of the garden, while not far away it was seeding abundantly in a piece of waste land. It does not root deeply, and the plants are easily destroyed, but a long wet spell, with somewhat of inattention, are sufficient for the weed to come boldly into evidence and quickly mature its seeds.

It will, perhaps, be a sort of comfort to the persons who are troubled with it in New Jersey to know that their friends and relatives in Massachusetts or Alabama or Oregon are not out of reach of this intruder, that has come up, in some unknown way, from a warm, distant country, and find, to our discomfort, a congenial abiding place among our better plants.

The Black Night-Shade.

There seems to have been an unusual amount of the black night-shade the present season, a fact that may be traced in large part to the wet weather of the year. The weed in question is one of the poisonous members of the family that furnishes us some of our leading truck crops, as potatoes, tomatoes, eggplants and red peppers, while among its ornamental members are petunias and matrimony vine. The whole family is made up of plants that are most abundant in the tropical countries, and with rank-scented herbage.

Within the genus Solanum the black night-shade is closely related to the bitter-sweet and is a first cousin to the horse-nettle and the Texas-nettle, so that it is akin to some of our worst of weeds. It is called the black night-shade (*Solanum nigrum* L.) because of the dark color of the berries when mature.

One correspondent writes, under date of September 23d, 1903: "I found after cutting some millet and going over the whole field that there is deadly night-shade from one end to the other, enough I should say, to destroy all the livestock in the State. Is the night-shade poisonous to cattle when dry? Will it be necessary to plow this field up and cultivate it for a year or two before growing any more grass on it? Does the night-shade live over—that is, does the

PLATE IX.

Weeds. The Galensoga is shown on the left, and Black Nightshade upon the right.

plant or root live over winter or does it come each year from the seed? The field, I am quite sure, has never had any in it before this season."

The fact that the pest in question is the *Solanum nigrum,* determined by specimens which were sent, upon request, to the Experiment Station, and that it is an annual plant, helped somewhat to solve the problem of eradication. The stock of plants for any year comes from seeds that have reached the soil in one or another of many ways. It is possible that in the instance before us the seeds came in with the millet, as is true with many kinds of weeds when they make their first appearance in a neighborhood. The weed may have been growing for years in some out of the way place nearby, and the seeds becoming scattered through the field awaited the conditions favorable for their growth. It scarcely need be said that the first step in the eradication is the destruction of all plants before they have time to mature seed either by cultivating the infested land or pulling out the night-shade by the roots. This method should give satisfactory results if continued for a few years until the seeds of the former seasons are disposed of, provided new seeds are not brought in by winds, animals or some by man as he sows his crop seeds.

The question of the poisonous nature of the weed is put very clearly by one correspondent, namely, "Will you please let me know if a small quantity of the night-shade should get mixed in with hay in the cutting would it be dangerous to feed it to cattle?" The whole plant contains the narcotic poisonous principle solanine, and for that reason it should not be fed to livestock. Just how much of the dried night-shade a grown animal can eat without ill effects is a matter that is very difficult to determine. Professor V. K. Chesnut,* as an authority upon the subject, states that "cattle seldom eat the plant, but a few cases of poisoning are recorded for calves, sheep, goats and swine," and again † he states: "The amount of poison present in any part of this plant varies with the conditions of growth. The more musky-odored are the most poisonous. The characteristic symptoms are about the same in man and animals. They are stupefaction, staggering, loss of speech, feeling and consciousness; cramps and sometimes convulsions. The pupil of the eye is generally dilated.

* Preliminary Catalogue of Plants Poisonous to Stock, Report of the Bureau of Animal Industry, U. S. Dept of Agric., 1898.

† Thirty Poisonous Plants, Farmers' Bulletin, No. 86, U. S. Dept. of Agric., 1898.

Death is due to a paralysis of the lungs, but fortunately but few cases are fatal."

The general appearance of the black night-shade is to be obtained from Fig. 2 in Plate IX.

Slime-Molds Upon Crop Plants.

There is a group of organisms that, in the latest systems of classification, lies very close to the line separating plants and animals, namely, the Myxomycetes or Slime-Molds. In their growing condition the members of this group are soft like jelly, and capable of movement, from which the common name slime is derived. After this amœboid stage is passed the slime changes into a very different condition, in which the spores are produced. It is on account of the method of reproduction that the slime-molds are generally considered as fungi.

In germination the contents of many spores unite to form the slime, often masses of considerable size, which lives ordinarily in moist, shady places, as under rotting logs and decaying leaves in the wood-lot. When the time comes for the stage of reproduction to be assumed the jelly-like masses often creep into the light and upon the upper side of logs, stumps and other objects. Such kinds of slime-molds do not feed upon living plants, and their presence upon growing leaves and stems only means that they accept what may be in their path.

Every little while specimens of these slime-molds are received at the Experiment Station, sometimes with questions that suggest alarm upon the part of the correspondents. The last box of these strange plants exhibited samples of strawberry leaves that were covered with a species kindly determined by Professor MacBride as *Diachea leucopodia* (Bull.), who says of it in his book:* "A very beautiful species; not uncommon in the Eastern States; rare west of the Mississippi. This species, as the Diacheas, generally affects fallen sticks and leaves in orchards and forests, and even spreads bodily over the foliage and stems of living plants."

That the general reader may be further acquainted with this peculiar plant, the engraving is presented (Plate X., left hand), which shows a portion of a strawberry leaf as bearing the sporiferous form of this slime-mold.

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*The North American Slime-Molds, pages 134-135.

PLATE X.

Slime Molds. A Diachea is shown at the left, and Physarum at the right; both upon Strawberry Leaves.

There are some members of the same group of plants that penetrate the tissue of living plants, and there propagate as parasites, and often produce malformations in the host. Of such are the club-root of the cabbage, turnip and allied plants, and often become quite destructive to crop plants. This subject has been considered at length, and the results have appeared in previous annual reports and Bulletin 98* of this department.

A somewhat similar species of slime-mold has been demonstrated by Professor Toumey † as causing the grown-gall upon peach, almond apple and other orchard fruit trees, and to which he gave the botanical name of *Dendrophagus globosus* Tou.

A second species of slime-mold that has been sent to the Experiment Station is shown in Plate X. (right hand). This was also sent to Dr. MacBride, who determined it to be *Physarum cinereum* Batsch., and of it he writes: "It occurs not infrequently on the leaves, stems and flowers of various herbaceous plants, by no means infrequently here [Iowa] on the leaves, etc., of strawberry plants. I suppose it finds sustenance on the decayed organic matter offered in the way of manure, and in this way only can it effect the welfare of the cultivated plant." The delicate nature of this mold can scarcely be shown in the photo-engraving, but something of the ashen-gray spore sacs can be seen covering the veins of the leaf.

Broom-Rape, a Weed Upon Greenhouse Tomatoes.

During last winter, or, more accurately, in the early spring, the experiment tomatoes in the greenhouse became seriously affected with the broom-rape (*Orobanche ramosa* L.). Some of the tomato plants had a yellow, sickly appearance some time before the parasite pushed its dark-olive tips above ground, and by the time the broom-rape was in full bloom the supporting tomato plant had ceased to grow, and, of course, did not mature any fruit. So abundant was this parasitic plant that it materially interfered with the experiments and was therefore, even though handsome and interestingly peculiar, a real greenhouse weed of the sort that is not easy to keep from doing injury, because its work is much under the cover of the soil.

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* Club-Root of Cabbage and Its Allies, December 9th, 1893.

† An Inquiry Into the Cause and Nature of the Crown-Gall, J. W. Toumey, Bulletin 33, Arizona Experiment Station, April 13th, 1900.

In the previous year a coleus plant was thus infested by the broom-rape, and a picture of the infested plant and its parasite was given in the last report; and the year before one tomato plant in the field was similarly affected. The seeds produced in the greenhouse by the specimen of broom-rape upon the coleus are probably responsible for the outbreak of the trouble upon the tomatoes the following season. The seeds are small and almost like dust in lightness.

THE ASPARAGUS RUST.

Observations as to the prevalence of the asparagus rust have been made from time to time upon the asparagus fields in the vicinity of the Experiment Station and by correspondence with those most interested in the industry throughout the State. Through the kindness of botanists and horticulturists in several other experiment stations, some additional facts have been obtained.

It will be gathered from the extracts that follow that generally there has been less of the rust this season than for the past few years, and the decrease may be attributed to the greater rainfall and consequent better conditions for a vigorous growth of brush.

Mr. J. G. Whitall, of Woodbury, New Jersey, under date of October 19th, reports for Southern New Jersey as follows: "The rust is not so bad on asparagus the present season as it has been in former years: in many cases where beds have been properly cared for they are still green and thrifty; where neglected they show more or less of the rust. Beds of some of the older varieties are brown and dead, and have been so for some time. The crop this spring was fair, but ran largely to cull grass. The price was good."

Mr. J. S. Collins, of Moorestown, New Jersey, under date of October 31st, writes: "We sprayed this season six times (not as many as last year). It shows some rust, mostly on the small leaves or limbs on under parts, but the bed has a green look and might be said looks well. I hope it may do well another year."

For the central part of the State, Mr. Charles Tindall, of New Monmouth, reports upon October 3d: "We find that the same conditions exist in regard to the production this year as last—that the least rust in the fall, with favorable climatic conditions in the spring, we have an increase in the amount produced. We have practically no rust this fall in our cutting beds in this section, and most of the

seedlings are free from it, with the exception of some that have not been properly cared for.

"While the climatic conditions and abundance of rainfall have had a tendency to give the plant strength to resist the disease, yet I feel encouraged to think that in a few years the rust will disappear entirely."

Mr. W. J. Morse, for Vermont, writes, under date of November 4th: "No specimens of this rust have been sent us this season, and we are unable to find any in the gardens around Burlington. Professor Stuart, our horticulturist, tells me that he has not seen any this year. The season here has been such that we have had very little trouble from fungi this year. The dry spring—no rain from the 1st of April until about June 10th—checked most such things, and the weather following was remarkably favorable for vigorous growth of strong, healthy plants." A week later the Professor kindly added that a bad case of the rust had just been reported to the Station authorities.

For Massachusetts, Dr. G. E. Stone writes: "The present season in this State has been much like the preceding, namely, it has been unusually cold, and there has been considerable rainfall. Previous to June vegetation suffered much from drouth. From June on, however, rain has been abundant. The rust has not been troublesome, and there has been much less than any year since it made its appearance.

"In looking over the College beds a few days ago (October 2d) we found, after considerable search, one or two small pustules containing teleutospores. Last year the rust was not perceptible on this bed until November, and undoubtedly we will not get very much on the bed this year until October or November.

"A number of beds in the Connecticut valley were examined by us September 2d, and no traces of rust could be found on any of the beds, although during our worst season of drouth, a few years ago, these beds for once showed a mixed stage of the rust, namely, teleuto and uredo, as early as August 25th.

"In the eastern part of the State, where rust has during some seasons appeared early and been common, the beds have been more free from rust this season than since the first outbreak. A large number of beds, examined by us September 5th, were looking remarkably green, and tolerably free from infection. On the whole, the last

two seasons have not been especially favorable for rust, and beds are showing a tendency to regain their old-time vigor.

"There are reasons for thinking the rust will actually become less common the next few years, and that the first outbreak will have proven the most severe. The most intelligent growers are now willing to admit that a little clay or slit in the soil renders infection less pronounced. Some attempt has been made to plant the so-called "rust-proof" varieties. We have also found rust on these varieties."

Dr. G. P. Clinton reports for Connecticut as follows: "I do not believe that asparagus rust has been as abundant this year as last. We have had no complaints, and I have found it only once."

Professor Stewart sends the following report for New York: "Concerning asparagus rust in New York State, I have to say that, on Long Island, asparagus rust is less destructive than at any time since its first appearance, in 1896. Some fields are slightly injured by it, but in the majority of the fields the damage done is inappreciable. It is also less destructive than usual in other parts of New York. Since June 7th the rainfall has been abundant throughout the season."

For Pennsylvania, Professor Buckhout reports: "The season has been wet throughout, and the growth of asparagus, after spring cutting stopped, very profuse and rampant. I went over our bed about October 7th, not presuming to make a thorough examination, and found no rust at all. A few days later others found a few infested stems only, and reported that they had gathered it all. Certainly it has not increased, presumably even lost a little over last year.

"We have done no spraying, and have cut very heavily from our bed. A small bed in my garden has not as yet shown any rust at all."

Professor J. B. S. Norton writes: "The rust is quite abundant in Maryland, although some fields are entirely free from it. The rust was apparently not so bad this year as last. Captain R. S. Emory, of Chestertown, Md., a prominent horticulturist and one thoroughly familiar with all classes of economic and scientific work, showed me last week (October 20th) an asparagus patch which was affected with the rust, but was still quite green, while adjoining patches were almost dead. He said it was kept up by cultivation and fertilizers.

"Some of our Eastern Shore asparagus growers have been quite successful in using power sprayers very frequently during the season after cutting."

Professor William B. Alwood, of the Virginia Experiment Station, reports: "I have not observed this rust anywhere in this vicinity,

except as noted last year in the gardens here at the College. We did not notice the rust until late in the summer, and soon as the plants were fairly mature we cut them off. We picked up every stem with great care, carried them off the gardens and burned them. This year we have not noticed a particle of rust on our plantation, but I am of the opinion that a minute examination would reveal some slight occurrence of this trouble."

Professor John L. Sheldon sends the following for West Virginia: "Asparagus is not grown in West Virginia to any considerable extent, but so far as my observations go the beds infested with the rust have been considerably weakened. The damage seems to be worse where *Darluca filum* accompanies the rust."

Professor A. D. Selby, of the Ohio Experiment Station, writes: "I can add little to previous reports. The rust has been sent to the Station from Hamilton county and from one or more additional counties within previously defined limits. Asparagus growers appear to look upon the rust more and more as a regular accompaniment of this culture. Methods of avoidance, rather than spray treatments, have been chiefly employed so far as reports to the Station indicate."

Professor B. O. Longyear, from Michigan, sends the following: "I have had only two plots of asparagus under observation during the present season; consequently cannot give any very careful points in regard to the rust. Conditions here have been very favorable for a vigorous and continuous growth of the plant due to the excessive rainfall. In both of the plots under observation the rust is present, but does not seem to be doing as much damage as in the ordinarily dry season. Whether this will hold true in all parts of the State or not I am unable to state, as the two plots mentioned are both in the vicinity of the Agricultural College. No remedies have been used on either of the plots mentioned. In the smaller plot the disease was almost entirely absent last season, which was also an unusually wet one, but was present to a considerable extent in the larger one, which was quite severe in both cases in previous seasons."

Dr. T. J. Burrill reports for Illinois as follows: "So far as I am informed the situation in Illinois in this matter is just about as it was last year when reported to you. The number of infected places are certainly as great as they then were, though in some instances diseased beds have been destroyed. I do not know of any instance in which the fungus has been eradicated by any less heroic measures than the entire destruction of the plantation, though it is certain

that the disease has not made the progress in places where it was introduced that was anticipated. Neither has it, upon the whole, been so damaging as it appeared to be when it first gained possession. Infected plantations are still kept in some places, and have made profitable returns without any direct treatment. In some other cases the use of Bordeaux mixture seems to be keeping it down."

Professor Albert Dickens, of the Kansas Experiment Station, sends the following report: "The rust has never caused any serious loss in Kansas fields, though it has been noted quite frequently. The fields which have come under my observation are apparently free from the disease. The College bed has been in good condition the last three years; some rust noted in 1901, but fair crops have been cut each year since. We have practiced burning the tops each fall as soon as dry, breaking down and burning with as little handling as possible. There are a number of large fields near here, and quite an area along the river near Topeka and Kansas City. All seem to be in good condition and have been healthy and productive the last few years."

Professor Shaw, of Oklahoma, sends the following: "The asparagus rust has not come under my observation in Oklahoma or Indian Territories, nor have any reports of its occurrence in this region reached me."

Professor L. R. Waldron reports for North Dakota: "The College bed was covered with straw in the fall of 1902 to a depth of eight inches after the asparagus had been burned. The fall was wet, and as a consequence some fermentation was set up in the straw. In the spring more fermentation took place and after the straw had partially dried it was burned, but it did not entirely burn off. The rust appeared in the bed to slight extent in July, but did not kill the asparagus until about the middle or latter part of August. In a large bed near the College no treatment was made, and the bed of asparagus was only partially burned during the preceding season. The rust appeared in this in July to a very destructive extent, in a more noticeable degree than in the College bed that had the straw application. Whether the straw was instrumental in checking it I cannot say. In general, the disease has caused more damage to asparagus beds in this State this past season than any preceding season."

Professor Aven Nelson writes as follows for Wyoming: "It is my pleasure to report again that no asparagus rust has come to my attention during the past season."

Professor Ralph E. Smith, of the California Experiment Station, writes: "In regard to the conditions of the asparagus rust in this State I would say that at present the disease is spreading rapidly and all the large districts are affected. It seems to have been here for at least two or three years, working from the south to the north. In the section about Los Angeles the disease is very bad, both on account of having been there for some time and also because of the local conditions. The rust shows in this State an absolute dependence upon atmospheric moisture, and in this southern district there is much more dampness than in many other parts of the State. In the sections where asparagus is grown for canners the disease is very bad in some parts and present in almost all. About San José, where there is considerable acreage, the rust appears to have been working for at least two years, while at the northern end of the district, at Sacramento, it has evidently arrived this year for the first time, although in the latter place the tops are now almost all dead. At Bouldin Island, where the Hickmott Company controls some 2,000 acres of asparagus, the rust arrived last year, doing considerable damage, and is now going on worse than ever. This point is intermediate between San José and Sacramento. There are several thousand acres of asparagus in the island district at the confluence of the Sacramento and San Joaquin rivers, and this is all becoming affected with the rust, so that altogether it may be said that the disease is now present in all the asparagus-growing sections of the State. There is no doubt that the industry will be very seriously affected, or perhaps exterminated, if we do not find some practical method of overcoming the disease."

Asparagus Rust on the College Farm.

Examinations of the four plots of asparagus at the College Farm were made almost weekly during the autumn months. The first signs of infection were observed upon October 1st, but the rust did not seem to increase during the month, and on the 1st of November it was still scarce, while the brush had a remarkably good growth and was of a healthy, dark-green color.

The final inspection was made upon November 3d, and the percentage of rust upon the several varieties was as follows: "Palmetto" and "Argenteuil," only a trace; "Mammoth," "Elmira," "Columbian," "Colossal," "Brunswick" and "Cross-bred," each 10 per cent.

Last year the percentages were 25 for the first two and 75 for the others, and the year before it was 20 and 50 per cent. for the same sets of asparagus.

EXPERIMENTS WITH SEEDS AND SEEDLINGS.

Since the greenhouse was established, in 1900, some experiments each season have been made with the germination of seeds. During the first winter the various dodders and other similar parasites were studied, and an outline of this work, with two page plates, appeared in the Report for 1901. Last year attention was paid to the germination of crossed corn, and particularly the white seedlings that are known as albinos and seem to be associated with close fertilization.

During the past winter tests in germination were made with squash and similar seeds. This is, in part, a continuation of experiments that were started some years ago and published elsewhere,* and from which some facts are here produced. For testing the time required for germination of various cucurbitaceous (squash-like) seeds, a shallow box, 20 by 36 inches, was filled with rich soil and placed upon a table in the laboratory, and the different kinds of seeds and the rate of germination are shown in the following table:

* Bulletins of Botanical Department Iowa Agricultural College, 1886, pages 30–35, and 1888, pages 20–26.

Rapidity of Germination.

Number.	KIND OF SEED PLANTED APRIL 9.	April 13.	April 14.	April 15.	April 16.	April 17.	April 18.	April 19.	April 20.	April 21.
1	Peerless watermelon	.....	....	.....	.....	.....	.....	......	.....	1
2	Boss watermelon....................	......	......	.....	......	....	......	.....	.....	2
3	Citron	....	......	......	.....	......	......	......	1	1
4	Early Russian cucumber..........	.....	6	7	7	9	9	9	9	9
5	Improved long green cucumber...	5	7	8	9	9	9	9	9	9
6	Gherkin..................................	.....	......	1	1	1	2	2	5	5
7	Dishcloth gourd......................	......	.....	.....	.....	1	1	1	2	2
8	Nest-egg gourd.......................	......	3	6	6	6	6	6	6	6
9	Dipper gourd...........................	.....	......	1	1	1	1	1	2	2
10	Cantaloupe muskmelon.............	......	......	2	4	6	6	7	7	7
11	Early Jenny Lind muskmelon....	.....	.....	1	3	5	5	5	5	5
12	Nutmeg muskmelon	......	......	....	3	5	5	5	5	5
13	Winter crook-neck squash.........	.....	......	3	4	5	6	6	6	6
14	Yellow-bush scallop squash.........	....	......	2	3	5	5	6	6	6
15	Hubbard squash........................	....	......	......	.....	3	4	4	4	4
16*	Hercules club gourd...	.....	.....	....	.....	.....	.....	.....	......	.....

The number of seeds was not uniform, as the large seeds were six for each kind, while of smaller sizes there was room for a dozen; therefore this is no test for vitality.

"The prompt response of the two cucumbers proper (Nos. 4 and 5) to the conditions furnished is marked. The watermelon seeds start slowly, if at all, under conditions seemingly satisfactory for the development of cucumber seedlings. The 'gherkin,' 'dishcloth gourd' and the 'dipper' are all nearly alike as to time. The 'nest-egg,' 'cantaloupe,' 'nutmeg' and all the squashes were slow, but sure. By the 18th, nine days after sowing, these rows had a fine showing

of plants. The last and slowest of all was the 'Hercules Club' gourd, which, with its large, thick-coated seeds, did not make any appearance above the soil until the 28th of the month, or nineteen days after the sowing was made."

One of the chief points of study in this experiment was that of the removal of the thick seed-coats with which this class of seeds is provided. The most satisfactory results were obtained by placing the seeds between folds of blotting paper kept constantly moist. The seed-coats open at the end that was attached to the fruit—that is, the "root" end—by the elongation of the primary root, which pushes out, and, if possible, at once turns downward. At the same time there is a lateral growth from the base of the stem, which now consists of a short zone of tissue separating the base of the root from the two large seed-leaves that still remain within the seed-coats. This side growth consists of a cushion of tough cells, without vessels of any kind, developed upon the lower side of the stem and spreading out upon the upper and inner end of the lower half of the seed-coat.

This curious contrivance was first described by M. Flahault in 1877,* and it did not escape the keen eyes of Mr. Darwin, who gave it the name of "peg," and writes of it as follows:† "A heel or peg is developed on one side of the summit of the radicle or base of the hypocotyl, and this holds down the lower half of the seed-coats (the radicle being fixed in the ground), whilst the continued growth of the arched hypocotyl forces upward the upper half and tears asunder the seed-coats at one end and the cotyledons are then easily withdrawn."

As the peg develops it exposes a thick layer of fine, branching hairs upon the side close to the inner coat, while the opposite or free surface is smooth and without hairs.

"Each of the outgrowths from the epidermal layer of cells of the lower surface of the peg is irregular in outline, often tortuous, frequently abounding with small, disc-like projections, and the extremities are club-shaped. The basal half of each hair is thick-walled and seemingly empty, while the younger and exposed irregularly-branching part is filled with granular protoplasm, which in its disposition and contents is identical with similar structures where glandular exudation takes place. This hairy surface of the peg becomes closely

* Bull. Soc. Bot. de France, XXIV., page 201.

† The Power of Movement in Plants, pages 102-105.

fastened to the inner coat, and as this coat is in close contact with the thick outer covering throughout its whole surface, it is easy to see that the peg in question has a firm attachment to the seed-coats as a whole. As soon as this peg has been developed and its attachment to the coat is secured, the seedling is in readiness to extricate itself from the thick and now worthless covering. The root continues to strike downward into the soil for support and anchorage, and produces lateral roots at many points on its way. The portion of stem above the peg, and between it and the cotyledons, which until now has been in comparative repose, begins to elongate. As the increase in length of this part of the stem continues, a loop is necessarily produced, the sharpest curve of which is outward from the seed-coats and upward from the peg. By continuing this elongation it is evident that so long as the peg holds on to the seed-coats the only part to give away is the cotyledon, and, as the result, these seed-coats are slowly and effectually withdrawn from their coats. Before this desired end is reached the loops may extend an inch or more above the seed-coats. In short, the soil is broken by the sharply-folded upper end of this loop, and not long after this the cotyledons are lifted out of the earth and raised to an upright position in the air and sunshine."

The most advantageous position for the seed in which to remove its seed-coats in germination has been sought for by extended trials. When, for example, the seed is planted with its root end downward, the seed-leaves, in many cases, will come above ground still within their coats, and such plants are sadly handicapped for further growth. A worse position is when the root end of the seed is placed upward, and particularly so when this end is near the surface of the ground. With these the young root must elongate upward for some distance, until it can make a turn downward, and this may bring it into the free air, when its moist, delicate substance is derived, and the seedling frequently perishes. The striving of these ill-placed seeds for a root-hold in the earth are sometimes painfully amusing. Seeds, when placed edgewise in the soil, must develop very wide pegs, that they may thereby catch and hold the edges of both halves of the seed-coats, and there may be a failure in this and the seed-coats are brought to the surface upon the cotyledons.

"There is a very practical bearing of these experiments upon the work of seed sowing. It is a common practice among gardeners and

farmers to prepare the 'hills' for the melons, squashes and other members of the gourd family, and then, with the thumb and finger, thrust the seeds endwise or edgewise into the soil. Should the seed be placed with the root end uppermost, and close to the surface of the soil, there is very little hope of a plant therefrom ever getting a good start. When the reverse is true, and the root end points directly downward, the plantlet experiences great difficulty in developing a peg that will remove the seed-coats. It has also been shown that seeds placed edgewise are not in a favorable position for the peg to act. It needs to be very wide, and then only the ends have an opportunity to hold back the vertical edges of the two halves of the seed-coat. The conclusion is evident that the best conditions are secured when the seed is placed upon one of its broad faces. This position is the one such seeds would take when left to fall naturally upon a level surface. Therefore, the 'hills' could be prepared as in the ordinary way, the seeds sown upon the leveled surface and afterwards covered with the required depth of soil. These conclusions are abundantly sustained by actual tests in the garden."

The seed-coats of some of the cucurbitaceous plants are provided with starch in the outer coat. All those of the "Hubbard" squash type, for example, are thus starch-bearing. The only place in the whole seed where this reserve food substance is stored is in the outer layers of cells of the two broad surfaces of the large white seed. When such seeds are placed in a solution of iodine the seeds take on a dark-blue color, because of this starch. In Plate XI. (upper third) is shown a number of kinds of squash seeds in pairs. The seed upon the left in each pair had been placed in iodine before the picture was taken, and the darker seeds are the ones that were colored blue from the presence of starch. All except the last four show starch in the outer coat. This placing of food substance upon the outside of a seed, and apparently out of reach of the embryo within, seems like a lunch provided for a person in a place in an overcoat that is not within reach. Some experiments have been made upon these starch-bearing seeds, the results of which are given below, but the end of the work has not been reached.

Experiments with Mutilated Squash Seeds.

"Hubbard" squash seeds were used, and the plan of the experiment was as follows:

Set *A*—	Five	seeds	untreated.
" *B*—	"	"	one-half (cotyledon end) removed.
" *C*—	"	"	shell removed.
" *D*—	"	"	root-end of shell removed.
" *E*—	"	"	tip (cotyledon end) removed.
" *F*—	"	"	starch coat removed.

The first planting was made February 2d, and, aside from mutilation, all the seeds were subjected to normal conditions. The first signs of germination were noted nine days later—February 11th—when the conditions of the several sets were as follows:

In Set A,	one seedling	breaking through.
" " C,	" "	" "
" " F,	five seedlings	" "

No signs of germination in Sets B, D or E.

A second seedling appeared in Set A and another in Set B.

The above series was duplicated in a second planting, February 6th, and eight days later—February 14th—four seedlings were breaking through in Set *A*, one in Set *E*, and three in Set *F*. A few days later the fifth untreated seed had germinated in Set *A*, and a fourth in Set *F*. No plants developed in Sets B, C or D.

The two trial plantings would suggest that the removal of the outer starch-coat from the squash shell has little if any effect upon the rate of germination or upon the vigor of the seedling plant.

On January 30th five scraped and five untreated squash seeds were planted in pots and subjected to the same conditions. On February 7th—eight days later—it was noted that there was a slight difference in the rate of germination in favor of the untreated seeds; four of which were out of the soil, erect and with cotyledons beginning to expand. The fifth seedling had just broken through the soil, and the cotyledons of the five seedlings from scraped seeds were not quite out of the soil. On February 12th there was some contrast between the two sets, owing to the "scraped" set being noticeably longer than the untreated, a difference which was to be seen up to the third week, when the plants were thrown away.

In another experiment a portion of the seed-coat was removed from one side of each of five squash seeds. The mutilated seeds were planted in pots February 6th, and at the same time five untreated squash seeds were planted in like manner; all of the mutilated seeds failed to germinate.

Seedlings of Martynias or Unicorn-Plant.

In connection with the crossing of martynias a study was made of the seeds and seedlings. The seeds themselves are very irregular in shape, due to being packed closely in the narrow cavities of the horn-like capsule, and, while nearly black, glisten at certain places upon their warty surface. The seeds are very slow and irregular in germination, and new seedlings will continue to appear in a seed-box for weeks and even months after the first have come to the surface.

One of the points of special interest in this connection is the presence of the heel or peg as has been mentioned for the squashes and allied plants. The peg has the same position upon the hypoctyl as in the squashes, and evidently performs the same function, namely, the removal of the hard, thick seed-coats from the cotyledons that would otherwise interfere with the development of the seedlings. A series of seedlings of the *Martynia Louisiana* Will. is shown in Plate XI. (middle third), giving the various stages of growth from a seed, with the root tips only extending beyond the hard, dark, rough seed-coat to a plant with the first pair of true leaves widespread. A study of these photographic reproductions will indicate the part the conspicuous peg plays in the germination of this plant. Purposely the empty seed-coats have been removed from some of the seedlings that the peg may be the better seen. In the three plants at the right, for example, the position of the empty seed-coats, as held by the peg, is quite naturally represented.

This provision for the removal of the hard, thick seed-coats from the martynia plantlets has been noted by Nobbe* with figure, and by Darwin in his book previously quoted. It only needs to be added that the importance of the peg is abundantly shown by any seedling that from any of several reasons has not been fortunate enough to leave the seed-coats attached to the peg, but instead bear them aloft upon the cotyledons, which are thereby prevented from expanding or the plumule from taking on its natural development.

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* Handbuch der Samenkunde, 1876, page 215.

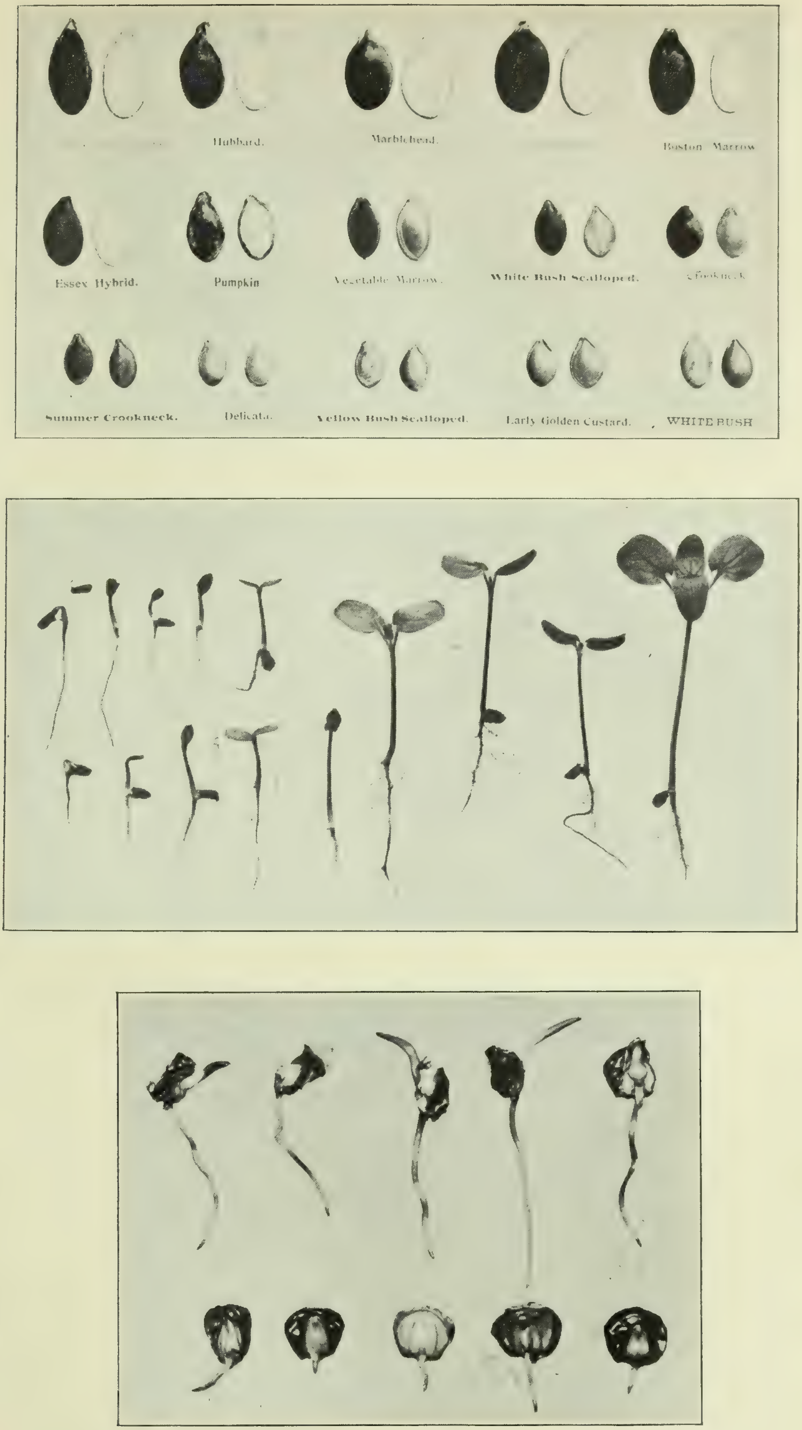

PLATE XI.

Seeds and Seedlings. *A*, Squash Seeds indicating starch in the seed coats. *B*, Seedlings of Martynia showing peg. *C*, Mutilated Corn as affecting germination.

Mutilated Corn.

A test was made of removing a portion of the starch from grains of corn. This was done by first soaking the grains until they were soft, when the edges were easily cut away, leaving only the embryo and the closely-adhering portion of the food material. Such mutilated grains, when placed under favorable conditions of warmth and moisture, produced the first root and young stem with greater rapidity than corresponding grains that had been left whole. Plate XI. (lower third) shows five seedlings of sweet corn forty-eight hours after the endosperm had been removed, while in the lower row are grains from the same lot as the first, and treated in the same way, excepting that they had been left uncut. It is seen that the upper row has produced three times as much root capacity and young stems of considerable length. In the lower row the stem growth is only slight.

This greater growth of the mutilated grains seems due to easier access of water, and the consequent more rapid formation of the solution of substances necessary for initial growth. In the long run the seeds, robbed of their substance, will suffer from lack of parental food.

THE POWDERY MILDEWS.*

The powdery mildews, of which there are at least thirty-five kinds in the United States, are recognized as forming a white powder upon the surface of the infested plant. The lilac is a shrub so common and generally attacked that it may be taken as an instance of showing the appearance of the mildews in question. After midsummer the previously smooth, clean, dark-green foliage takes on a gray color, as if coated with a whitish road dust.

The mildew consists of microscopic threads, that grow along close to the surface of the leaf, and send up short, upright stalks, bearing minute spores, which, in large numbers, give the appearance of flour dusted upon the plant. Later in the season the white coating may be replaced, in large part, by a second form of spore-production, which is usually brown. Thus there are two sorts of spores, one being nearly white, in mass, and produced rapidly in summer for

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*Mildew is an old English word that has a similar form in the German Mehlthau, meaning *meal-dew.* One can easily imagine the fine meal or flour having fallen in minute quantity upon the affected herbage.

the spread of the mildew, and a second form that matures slowly, perhaps requiring months for this, and remains over winter before they start into growth.

Expert rose-growers can detect the rose mildew in the greenhouse possibly before it is at all apparent to the eye. There is a peculiar odor to this group of fungi that is not met with elsewhere, and a leaf badly affected with the summer form gives off this odor so strongly that, when it is held close to the nose, the diagnosis is unquestioned.

Several of our serious plant diseases belong among these mildews, and in the following paragraphs they are considered somewhat at length.

Their Classification.—The kinds of powdery mildews are not numerous. According to Salmon there are only forty-nine species and eleven well-marked varieties known in all the world. The differences between the kinds are chiefly microscopic, and belong mainly to the penthicia and their contents. In other words, the mildews, as they first appear from the germinating spore, usually in early summer, are all very much alike, and a student of the subject does not feel that the species or genus can be certainly determined without the so-called "winter fruit." The case is somewhat similar to the classification of apples or pears, peaches or blackberries, without their fruit. The vegetative portion of the mildew corresponds to the stems and leaves of the trees or shrubs, the summer spores to the many buds, and with only these the kind cannot be definitely known. Some plants bear quite generally mildews which fail to produce the winter spores, and in all such instances it is uncertain what species of mildew is present. An interesting case is the European grape mildew, which was named *Oidium Tuckeri*, by J. M. Berkeley, in England over a half a century ago (1845). Since that time the mildew has been very destructive to the grape industry throughout Europe, Asia and the United States, but not until 1892 were the penthicia found associated with *Odium Tuckeri* in the vineyards of France. In the meantime a mildew was found upon grape vines here in America that produced the "winter fruit," but the question of the identity of the American and European form was not generally admitted, and the conclusion was only reached by finding both kinds of spores upon the grape in the home of the Oidium.

To bring the matter closer home, the writer has a matrimony vine upon his house piazza, that mildews each late autumn, but after the

most diligent search I have failed to find the least sign of the "winter fruit." If one should ask for the history of the species here represented in the rapidly-spreading summer form, no positive answer could be given. There is a species (*Microsphæra Mougeotii* Lev.) upon the same host that is as yet recorded only for Europe. It is seen that it is the reversed case of the *Oidium Tuckeri*, above mentioned, and it remains to find the "winter fruit," or, failing in this, to call it by the name of the last species mentioned, with a question mark added, or name it *Oidium Lycii* tentatively.

The classification of the species, as previously stated, is founded chiefly upon the perithecia, their appendages and contents. First, certain species, along with other characteristics, have but one spore sac in the penthicium, thus making two primary groups of the mildews. Second, the appendages are unbranched, branched, sharp-pointed or with curved tips. By means of these few characters the species are separated into six genera, as shown by the following key.

Spore sac in penthicium one—

Appendages, branched... *Podosphæra.*
Appendages, unbranched .... *Sphærotheca.*

Spore sacs in penthicium more than one—

Appendages, curved .... *Uncinula.*
Appendages, branched... *Microsphæra.*
Appendages, unbranched... *Erysiphe.*
Appendages, needle-shaped...................................... *Phyllactinia.*

These six genera are represented in the United States by the following number of species:

	Species.		Varieties.
Podosphæra..........	3	and	1
Sphærotheca..........	5	"	1
Uncinula..........	9		...
Microsphæra..........	5	and	4
Erysphe..........	6		...
Phyllactinia..........	1		...
Total	29		6

After the genus has been determined, which is a very easy matter as a general rule, another set of characters is considered, and here the greatest care is required. Let us take the mildew of the lilac for a consideration of the specific marks. For these a compound micro-

scope is required that is provided with a measurer (micrometer), by means of which the average size of the penthicia is determined—66 to 135 micromillimetres* in diameter. The number of the spore sacs within the penthicium—3 to 8—is determined and their shape globose and size 42–70 by 32–50u. Next the spores, 4–8 in each sac, are measured (18–23 by 10–12u), and then attention is directed to the number, position and size of the appendages or holdfasts of the penthicium, particular account being taken of the unusually complex forking at the tips. When specimens agree with the description suggested in the above outline they are considered as belonging to the genus Microsphæra, and the species *Microsphæra Alni* (Wallr.). The generic name Microsphæra means *little sphere*, as suggested by the shape of the minute penthicia, and the specific addition Alni is from Alnus, the Latin for alder, upon various species of which the mildew is common.

It might be thought an easy matter to determine the species directly from a known list of the plants upon which it has been found. This method might answer the purpose, provided that only one kind of mildew infested any grown host. For example, the oaks are generally attacked by the *Microsphæra Alni* (Wallr.), but also by three other species, and two varieties of the one in question. The only safe way is to give each specimen of mildew a searching microscopic examination.

Their Development.—Unlike the rusts, smuts and various deeply-seated blights, the powdery mildews, as stated before, are superficial and their growth is easily watched. Starting at a point where the spore has fallen, the mildew is first noticed as a speck, and this rapidly enlarges to the size of a dime, retaining its circular form unless meeting with the rim of another advancing colony when irregular shapes are produced. The spreading may continue until the whole infested area, whether leaf or stem, is coated over. It is frequently easy to see without a glass the radiating lines which converge here and there in the points of original attack. In like manner the spore cases may be seen formed along the main threads or "spokes" and giving to the coating of mildew something of a starry appearance. Some of these characteristics may be seen in the representations in Plate XII.

The rate with which the mildew develops depends upon the kind of mildew, of host and the surroundings of heat and moisture. Upon

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*A micromillimeter designated by the Greek letter u—mew—is one twenty-five housandth ($\frac{1}{25000}$) of an inch.

PLATE XII.
Views of Powdery Mildews.

certain of the most susceptible of the tender roses the growth is so rapid that the young leaves are nearly covered with the mildew in a day or two after it is once started. Some rose-growers associate its appearance with an improper ventilation of the greenhouse, and claim that it can be produced with certainty by drafts of outside air striking the plants when all the other conditions are favorable for the spread of the mildew. However this may be, the fact must not be lost from sight that it is a germ disease and the source of contagion consists in spores that fall upon the surface of the susceptible plant. Spores, like seeds, require certain conditions for their germination, and when these obtain they grow and sometimes with wonderful rapidity.

Soon after the spore has germinated it sends suckers into the host whereby the mildew plant derives its nourishment and is able to spread its cobwebby threads along the surface. Shortly it begins to produce upright branches which bear spores at their tips. The time from the germination of the spore and the beginning of an infection spot to the production of a crop of spores is measured by only a very few days, and this helps to explain the rapidity with which the fungus covers a whole plant or fills a rose-house with the mildew.

The production of the spores, as above mentioned, continues indefinitely and in numbers beyond computation. They are the "summer spores," and designed for rapid germination during the growing season. A second form of spore is very different from this and arises slowly within the perithicia before mentioned. These are called the "winter spores," and are designed to pass the winter as such and germinate the following spring or summer. The spore-case arises from a union of threads, and, after producing a nearly spherical shell, the spores are developed in sacs within. Situated as they are within the sacs, which in turn are inclosed by the thick, brown wall of the perithicium, the spores are protected from the destructive elements, like peas in their pods, the pods being in, for example, a tightly-covered basket.

Upon some plants only the summer form of spore is found, but as a rule the perithicia are formed late in the season, and by the time the leaf is ready to fall the white of the early appearance of the mildew is replaced by the brown of the perithicia, which in some instances are so numerous as to almost cover the whole infested surface of the host. This thick, brown coating of the leaf in autumn is suggested in the picture of the phlox leaf at 4, in Plate XII.

Their Distribution.—The powdery mildews are all parasitic, and their abundance in any locality depends largely upon the character of the flora. Certain groups of plants seem to be entirely exempt from their attacks, and where these abound the mildews naturally are less numerous than where the susceptible plants prevail. Thus no mildews are met with upon the ferns and their allies. None prey upon the pines and related cone-bearing plants. In like manner the long-leaved plants, like rushes, sedges, lillies and orchids are exempt, excepting the single family of grasses, and here but one species of mildew is found. Therefore, the pine forests and the bogs, where mosses, ferns and grass-like plants make up the vegetation, are practically free from mildews. But in localities where the plants are of the sorts other than those just mentioned, the mildews may be expected. According to Professor Salmon,* in his recent exhaustive study of the group, "the headquarters of the mildews are in the North Temperate zone, as they occur in the greatest numbers in the United States and parts of Europe." It should be borne in mind that it is only within a short time that mildews have been carefully studied, and in the vicinity of old botanical centers they are better known than elsewhere. In other words, the mildew flora of Europe is much better known than of Africa or Asia. With us the subject has been more advanced in New England than the Dakotas or Texas. In short, there are areas in the United States where the mildew hunter has not been, and therefore it is too soon to dwell at length upon the distribution of these fungi in our country from the economic standpoint.

Some species have been found upon but a single host. Thus, for example, the *Podosphæra biuncinata* C. & P. is a strictly American species, described in 1872, and met with only upon the leaves of the witch hazel (*Hamamelis Virginiana*). A glance at the herbarium shows specimens from the following States: Vermont, Massachusetts, New York, Indiana, Illinois, Wisconsin, North Carolina, Alabama. It goes without saying that the range of this mildew depends upon the distribution of a single species, unless future search should determine some other host for it. Illustrating the same point, and of more economic importance, is one of the mildews of the apple. *Podosphæra leucotricha* (E. & E.) Sal., which is confined to our common apple (*Pyrus malus*) and another species (*Pyrus Sieboldi*) and

*A Monograph of the Erysiphacea, by E. S Salmon. Memoirs Torrey Botanical Club, New York, 1900.

is found in Europe, Asia, Japan and the United States. *Spærotheca phytoptoptrylla* K. & S. is a recently-discovered American species, described in 1888, which has been found only upon the hackberry (*Celtis occidentalis*) and only associated with the distortions of the branches due a gall mite (*Phytoptus*). This limitation contrasts greatly with *Erysiphe Cichoracearum* DC., which is a world-wide species, described with its present scientific name in 1805, thriving upon a long list of hosts. For example, in the United States it has been found upon 105 species of plants. It is this species that mildews the ragweeds, asters and goldenrods in the fields and neglected land, and the dahlia, sunflower and cucumber among cultivated plants. The *Microsphæra Alni* (Wallr.) is an old species, with a very wide range of hosts in sixteen different families of plants, usually, however, upon trees or shrubs. This species has been mentioned in the opening paragraph as the mildew of the lilac. It is quite generally upon the nut trees, birches and has a special liking for the dogwoods and viburnums. Having such a long list of hosts, it is not surprising that it is met with in Europe from Italy to Norway, as it is with us from Maine to California and Manitoba to the Gulf.

Powdery Mildews of the Orchard.

The leading powdery mildews of the orchard are *Spærotheca pannosa* Wallr., which grows upon the peach, and *Podosphæra oxyacanthæ* (DC.) DBy. upon apple, cherry and plum. The mildew of the peach is not very common, but has been abundant the present season. It appears upon the young twigs and their younger leaves, covering all with a thick, white coat, while the leaves are prevented from making their normal growth and are sometimes distorted, suggesting the work of the leaf-curl parasite, which, however, is a very different fungus. The peach mildew is found upon only a few species of plants, the roses being the chief of these, and the subject will be considered again in this paper.

The mildew of the apple, plum and cherry is, in appearance, similar to the one of the peach, but very much more common and destructive. It is most frequently met with upon the cherry, the young leaves of which in autumn are often whitened with it and more or less dwarfed and distorted. Young trees seem more disposed to the mildew than

older ones, and nursery stock is sometimes severly injured by the pest.

Many experiments have been made with various solutions, and none are more effective than the standard Bordeaux mixture.

This mildew has wider range of hosts than the one upon the peach, and may be found upon various species of spireas and hawthorns, while the quince is occasionally affected. All of these plants are closely related to the apple, cherry and plum.

Powdery Mildews of the Fruit Garden.

The leading mildew of the small fruits is *Sphærotheca Mors-Uvæ* (Schw.) that preys upon the gooseberry. It differs somewhat in habit of growth from the others because it forms a thick, brownish covering upon the canes, leafstalks and the fruit. While it is found upon several of our native species as growing in the wild state, it is unusually destructive to European cultivated varieties, and has been a serious check to the extensive cultivation of these latter sorts in America. Professor Salmon, in a recent letter, stated that this mildew is upon the increase in Ireland and becoming a serious pest. Very good results have, however, attained the use of fungicides, and among them that of sulphide of potassium has proved satisfactory. This is a simple solution, easy and cheaply made and may be employed without the risk that obtains with some others.

The powdery mildew of the grape (*Uncinula necator* Schw.) is found upon several of the wild species and also infests the American ivy, a near relative of the grape. While this mildew may appear upon the fruit and canes, it is usually confined to the leaves, and there is not conspicuous, particularly upon the woolly sorts. In America this fungus is not very serious, but in Europe it has been among the worst enemies of the grape, and the amount of its destruction in a single season is truly vast. With the present knowledge of methods of treatment with fungicides there is no longer occasion for alarm.

The strawberry is occasionally infested with a mildew *Spœenthica Humuli* (DC.) var. *fuliginea* (Sachkt.), but as yet it has not become serious.

Powdery Mildews of the Vegetable Garden.

The cucumber is sometimes troubled with a powdery mildew (*Erysiphe Cichoracearum* DC.), and the same species is occasionally met with upon the pumpkin. Garden peas, particularly the late sorts, are badly infested with *Erysiphe Polygoni* DC., a mildew of wide distribution and growing upon nearly sixty kinds of plants. Experiments show that it can be controlled by fungicides. The beans of various sorts usually escape from the attacks of this mildew.

Powdery Mildews of the Greenhouse.

The leading powdery mildew that makes trouble for the grower of plants under glass is the *Sphærotheca pannosa* Wallr., which quickly produces white patches upon the rose leaves. It is distributed throughout the world and upon many species of roses, the peach being the only other host plant, outside of the rose genus, thus far known to be infested by this mildew.

There is another species of mildew upon roses, namely, *Sphærotheca humuli* (DC.), and therefore there is much confusion between these two last-named kinds, because the determinations are carelessly made, without a study of the perithecia, which are often omitted in the development of the mildew.

The second species of mildew pestering the greenhouse plants is *Erysiphe Cichoracearum* DC., which thrives upon the cucumber and other plants of its family, and asters, dahlias, zinnias of the composite family, probably including the chrysanthemums. The last in an interesting case of the rank and destructive growth of the conidial, or summer form of the mildew, while the "winter fruit" is omitted. Until the latter perithecia can be found, the old name of *Oidium Chrysanthemum* Rabenh. will be retained to designate this pest. In a similar way, *Oidium leucoconium* Desm. was the name for the rose mildew until its final determination was made.

The mildew of the cucumber and the chrysanthemum (?) is very destructive to indoor phlox, and something of this host and its pest will be said under the head of "Remedies."

Powdery Mildews of the Field and Forest.

The field and forest encircle the plants that have not been mentioned elsewhere. Of the grains and grasses there is but one mildew that has yet been recorded, namely, *Erysiphe graminis* DC. This is frequently met with upon redtop, blue grass, oats, barley, wheat, etc., and should any new host for mildew be found among the grasses, it would most likely be infested with this same species. However, as before stated, the only safe way is to make a microscopic examination of the winter fruit and compare results with the descriptions of the various recorded species.

In a similar way, there is one species that is particularly fond of the members of the great sunflower family, and is, therefore, the mildew of a large list of our worst weeds. This is the *Erysiphe cichoracearum* DC., and may be generally seen whitening the foliage of sundry ragweeds, fleabanes, solidagos, asters, ironweeds and cockleburs. It is also often upon the verbenas of the field and the garden species as well, and the same way with the kinds of phlox, wild and cultivated. This mildew is among the worst, because there are so many wild plants that harbor it just outside of the garden fence, or even in the garden, when the latter is not kept free from weeds.

Another instance of the last-mentioned fact is in evidence with the mildew of garden peas, namely, *Erysiphe Polygoni* DC., which has many hosts among the most common of our weeds, as, for example, the various buttercups, meadow-rues, lupins, vetches, certain clovers, geraniums, evening primroses and columbines, besides several smartweeds. It is evidently a hard matter to keep such a species of mildew in subjection.

There are two species unlike the last-mentioned that chiefly infest the woody plants. Thus the *Phyllactinia corylea* (Pers.) is at home upon birches, alders, chestnuts, oaks, elms, hawthorns, maple, ash, catalpa, etc., and among vines the waxwork (*Celastrus*). The *Microscophæra Alni* (Wallr.) has a similar wide range of trees and shrubs, and when any of the hosts are introduced to the ornamental grounds the mildew does not leave it untouched.

The genus Uncinula has some well-marked species that are very limited in number of their hosts—one is upon maples, another upon basswood only, another upon the horsechestnuts and buckeyes, one

upon mulberry only, one upon the vines, American ivy and grape, two others upon the hackberry only, and the most common species of all (*Uncinula Salicis* DC.) is limited to poplars and willows.

Remedies for the Powdery Mildews.

The powdery mildews were among the first economic fungi to be systematically combated by substances inimical to them.

Until 1880 sulphur was the substance that was used for this purpose and with good results, particularly for the mildew of the vine, then known as *Oidium Tuckeri,* and of the rose and other susceptible plants under glass. The sulphur was applied as a powder, dusted in various ways upon the plants, and by means of the fumes which slowly arose the mildew was checked in its growth or killed. The methods of application are many. Professor Maynard* uses "evaporated sulphur," as follows: "A small kerosene stove, with a thin, iron kettle was used, and the sulphur kept boiling two or three hours thrice each week, when the house was kept closed. Care must be taken that only enough heat is used to boil the sulphur and that it is not set on fire."

It is thought by many to be more convenient to apply the remedy as a spray, and for this purpose any of the standard fungicides may be employed. The Bordeaux mixture, while effective, is not to be recommended for indoor plants like roses, as it leaves a discoloration of lime that is objectionable.

During the past two winters the experiments with kerosene emulsion indicate that this compound is effective and at the same time does not leave any stain upon the treated plants. A statement of these results is given in a recent bulletin† from this department.

As an illustration of the susceptibility of the powdery mildews to the toxic effects of fungicides, the following experiment is cited: The plants involved in the trial consisted of twelve seedlings of the Drummond phlox, each in a separate flower-pot. Six of these, six plants in every way as nearly equal as possible to the other six, were subjected to treatment, while the duplicate half dozen were placed alongside and subjected to all surrounding conditions, excepting the single one, of the spraying the first six received.

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*Treatment of Mildews upon Plants Under Glass, Journal Mycology, Volume VI., pages 16-17, 1891.

† No. 157. Some of the Newer Fungicides, June, 1903.

A pound or so of copper turnings, used for various experiments where metallic copper is required, and kindly furnished by the Professor of Physics in the College, was placed in a large glass jar and covered with distilled water, a glass cap being fitted over the jar. From this jar the water was used for spraying the six plants at intervals of about one week, until the experiment terminated after two months.

It was observed that the long contorted strands of copper soon lost their native color and became dark in the water, but no apparent taste was imparted to the liquid. No chemical tests were used in the experiment. As the weeks passed there began to be a difference in the amount of the mildew upon the two sets of plants, the untreated ones becoming coated thickly with fungus. It should have been added among the conditions that the whole set of twelve plants were placed near the bed where the main experiments with the mildew were in progress, and there was no lack of spores for a rapid and thorough infection.

At the conclusion of the experiment two average plants from each of the lots of six were selected, and, after being placed in a row, with the sprayed two in alternation with the two untreated, a photograph was secured that is reproduced in the engraving (Plate XIII.), with, however, much loss of the striking effect as seen in the specimens themselves. In short the plants treated with the "copper water" were much less infested by the mildew, and as a consequence had a more healthful appearance and produced normal blooms, while the untreated plants were literally covered with the fungus, and the hope for blossoms practically passed.

The above facts are stated without any application of the theories of modern chemistry to account for them. This experiment calls to mind one made some years ago with the germination of spores, as recorded in the report for 1891, page 289.

The tests were with the spores of the common cherry rot (*Monilia fructigena* Pers.), which would germinate in two hours or less, and the following is reproduced as a partial explanation of the possible toxic action of the copper water when sprayed upon the phlox plants that were constantly subjected to inoculating spores of its favorite mildew:

"The substance tested was the ammoniacal carbonate of copper compound, and of various strengths, beginning with the strongest—

PLATE XIII.
Phlox Plants used for testing "Copper-water" for Powdery Mildew.

that is, three ounces of the carbonate of copper to one quart of ammonia. By this the spores were killed, as also by the half, fifth and twentieth strength. An extreme dilution was then substituted, namely, a one per cent. strength of the fungicide, as used for spraying grapes, etc.—that is, one part of the ordinary vineyard strength was added to ninety-nine of pure water, which gave a liquid that contained so little copper as to require a most delicate chemical test to detect its presence. In such a solution the spores would not germinate, but after several days, when the spores were washed five times and placed in pure water, they grew slowly. In order to carry the tests a step farther, slides with pit cells were arranged, with pure water in each, but into alternate ones a small bit of polished copper foil was dropped, the piece being in area equal to that of the lead at the end of a Faber pencil. That the presence of this minute amount of metallic copper should prevent the germination of the spores was surprising, and only after many trials was the fact accepted. In only one case in a score or more was any spores with the copper found with germ-tubes, and in this they had probably formed before the sowing was made. In no instance was there any failure of the spores to grow in the check-cells with pure water only. That there might be no chance of any oxide of copper or other soluble compound being present, the foil was thoroughly scoured and rubbed to a bright polish. After the bit of copper was removed and the water changed, the spores would sometimes germinate, the degree of activity depending somewhat upon the length of time they had been held in check.

"If now, in place of pure water in a fresh preparation, a percentage of cherry juice is added to the slide-well, the spores grow, the rate depending upon the amount of stimulating fluid added. A point could doubtless be reached at which the action of the nourishing fluid would just equal that of the copper, and the spore would remain alive and inactive indefinitely.

"While at first sight there does not seem to be any practical bearing for these results, upon a further consideration it may teach the truth that fungicides, as at present employed, are far stronger than they may need to be. If a bit of metallic copper in pure water will hold its own weight, or many times that of spores inactive, it seems likely that the time has come to try a weaker solution of copper.

"Since the above was written opportunity has offered to test the spores of a species of Fusarium and those of *Cercospora Apii* Fr., the

celery blight, both of which germinate with remarkable rapidity in water. When surrounded with their congenial food—that is, an extract of the host plant—the rate over that of pure water is augmented many times. When copper is added to the water the spores fail to germinate, or, in short, the results are the same as those reported for monila.

"Similar experiments have been made with metallic zinc, but even when the spores were literally surrounded by the granulated metal they grew with vigor. A powdered form of metallic zinc was also used, and even in abundance had no retarding effect."

For the out-of-door mildews, particulary the *Sphærotheca mors-uvæ* (Schw.), there have been many trials made with a long list of substances. At the New York (Geneva) Experiment Station this pest has been under treatment for some years. The following is quoted from the Bulletin No. 161:* For three seasons Bordeaux mixture, lysol and formalin have been compared with potassium sulphide, the latter giving the best results in all three series. The recommendation is to use potassium sulphide, one ounce to two or three gallons of water, and the spraying should begin just as the gooseberry buds are opening and be continued at the usual intervals of ten days.

It is not unlikely that good results would obtain with the potassium sulphide upon garden phloxes or any other of the affected hosts for the powdery mildews.

In Plate XII., Fig. 1, is shown a lilac leaf with the mildew (*Microsphæra Alni*) in a young condition upon the upper side. The somewhat circular spots are so many developments from points of inoculation. Over some areas of the leaf the circles of spreading fungous threads have met with others, and a nearly uniform coating will in time result. This is particularly true of the left half of the leaf above the middle, while upon the right is a portion of the leaf with but few mildew patches, and a very small one may be distinguished like a star in an unaffected area of the leaf.

At 2 is a leaf of the ordinary dooryard plantain, showing, in young condition, the very common species *Erysiphe Cichoracearum* DC. as it develops upon the upper side of the leaf. It also illustrates the preference shown for the veins, as it is seen that the patches center along these lines, possibly because of the greater amount of moisture here met with upon the surface.

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* Treatment for Gooseberry Mildew, by C. P. Close, November, 1899.

The winter spores that form after the mildew has vegetated for a time are quite frequently upon the under side of the leaf, and in many instances only found then. Plate XII., Fig. 4, shows the under side of a leaf of garden phlox, upon which, as the leaves are ready to fall, the perithecia are in abundance, and may be seen as small, dark specks, the indistinctness being partly due to the surrounding brown threads that partially envelop the spore-cases. Sometimes the perithecia entirely coat over the surface of the leaf, and, as each of these cases contains many spores, it is no wonder that the mildew is kept over the winter and is ready to begin life anew when another season, with fresh foliage, is at hand.

An under side of a lilac leaf is shown at Fig. 3. This leaf was gathered some weeks later than the one shown in Fig. 1, and after the under surface had become evenly coated with the mildew threads and upon which the dark spore-cases formed. In the lilac the perithecia are less enveloped by brown threads and the minute dark spots are therefore more evident. Unfortunately the leaf is reduced below natural size, or else the perithecia containing the winter spores would be more clearly seen.

Below is given a preliminary list of the species of powdery mildews of cultivated plants, with the leading hosts under each. Following each host name is given the abbreviations of the States in which the plant has been recorded with the mildew upon it. The list of papers consulted follows at the close of this article.

I. PODOSPHÆRA. *Kunze* (1823).

1. *Podosphæra Oxyacanthæ* (DC.), De Bary.
   Erysiphe Oxycanthæ DC. (1807), as above, 1870.
   Pomaceæ, Cratægus Sp.—W. Va., Ind., Ill, Ala., Can.
   Pomaceæ, Malus Malus (L.)—Vt., Mo., Ala.
   Pomaceæ, Pyrus Cydonia L.—Ind.
   Drupaceæ, Prunus Cerasus L.—N. Y., N. J., O., Ind., Ill., Ala., Neb., Kan.
2. *Podosphæra leucotricha* (E. & E.) Salm.
   Spærotheca leucotricha E. & E., 1888, as above, 1900.
   Pomaceæ, Malus Malus (L.)—Vt., Mo.

II. SPHÆROTHECA. *Leveille* (1851).

3. *Sphærotheca Humuli* (DC.) Burr.
   Mucor Erysiphe Linn (1753). Erysiphe humuli DC. (1815), as above (1887).
   Moraceæ, Humulus Lupulus L.—Ala., Wyo., Cal.
4. *Sphærotheca Humuli* (DC.) Burr. *var. fuliginea* (Schlecht) Salm.
   Alphitomorpha fuliginea Schlecht, 1819, as above, 1900.
   Rosaceæ, Fragaria cult.—N. Y.

5. *Sphærotheca pannosa* (Wallr.) Lev.
Alphitomorpha pannosa Wallr., 1819, as above, 1851.
Rosaceæ, Rose Sp.—O., Ind., Ill., Wis, Ia., Ala., Dak., Colo., Cal.
Drupaceæ, Prunus Persica S. & Z.—N. Y.
6. *Sphærotheca Mors-Uvæ* (Schw.) B. & C.
Erysiphe Mors-Uvæ Schw., 1834, as above, 1876.
Grossulariaceæ, Ribes Grossularia L.—Vt., N. Y., N. J., O., Can.

III. Uncinula. *Leveille* (1851).

7. *Uncinula Salicis* (DC.) Wint.
Erysiphe Salicis DC., 1805, as above, 1884.
Salicaceæ, populus tremuloides L.—Vt., O., Ind., Ill., Wis., S. D., Mont.
Salicaceæ, Salix cordata Muhl.—Vt., O., Ill., Ind., S. D.
Salicaceæ Salix Sp.—Mass., N. Y., N. J., O., Ind, Ill., Wis., Minn., Ia., Dak., Wyo., Mont, Cal.
8. *Uncinula necator* (Schw.) Burr.
Erysiphe necator Schw., 1834, as above, 1892.
Vitaceæ, Parthenocissus (Ampelopsis) quinquifolia L.—Vt., N. J., W. Va., O., Ind., Ill., Wis., Ia., S. D., Neb., Kan., Can.
Vitaceæ, Vitis cordifolia Michx.—W. Va., Ind., Wis.
Vitaceæ, Vitis vinifera L.—Cal.
Vitaceæ, Vitis Sp.—Mass., N. Y., N. J., W. Va., O., Ind., Ill., Wis., Ia., Ala., Neb.
9. *Uncinula circinata* C. & P. (1872).
Aceraceæ, Acer saccharinum L.—Vt., N. J., O., Ind., Wis., Ia, Mo., Neb.
Aceraceæ, Acer saccharum March.—O., Ind., Ill.
10. *Uncinula macrospora* Peck. (1872).
Ulmaceæ, Ulmus Americana L.—Vt., O., Ind., Ill., Wis, Ia., Mo., S. C., Ala., S. D., Kan., Can.
11. *Uncinula flexuosa* Peck. (1872).
Hippocastanaceæ, Æsculus glabra Willd.—O., Ind., Mo., Miss.
Hippocastanaceæ, Æsculus Hippocastaneum L.—Vt., N. Y., Ind.
12. *Uncinula Clintonii* Peck. (1872).
Tiliaceæ, Tilia Americana L.—Vt., N. Y., Ind., Ill., Wis., Ia., Can.
13. *Uncinula geniculata* Ger. (1873).
Moraceæ, Morus rubra L.—N. Y., Ind., Ill., Mo., Ala.

IV. Microsphæra. *Leveille* (1851).

14. *Microsphæra Alni* (Wallr.) Salm.
Alphitomorpha panicillata var. alni Wallr. 1819, as above, 1900.
Juglandaceæ, Hicoria (Carya) alba (L.)—Ill., Mo., Miss.
Juglandaceæ, Juglans cinerea L.—Ill.
Juglandaceæ Juglans nigra L.—Ind., Ill., Miss.
Fagaceæ, Castanea dentata Marsh.—W. Va., O.
Fagaceæ, Castanea sativa Mill.—N. C.
Fagaceæ, Fagus Americana Sweet.—Vt., N. Y., W. Va., Ind, Ill., Wis., Ala.
Ulmaceæ, Ulmus Americana L.—Ill.

Platanaceæ, Platanus occidentalis L.—Vt., O., Ill., Ind., Mo., Ala., Miss., Kan.
Cæsalpinaceæ, Gliditsia tricanthos (L.)—O., Ind., Ill., Ala., Miss.
Celastraceæ, Euonymus atropurpurea Jacq.—O., Ind., Ill., Mo., S. D., Neb.
Rhamnaceæ, Ceanothus Americana L.—Vt., Ill., Minn.
Oleaceæ, Syringia vulgaris L.—Vt., Mass., N. Y., O., Ind., Ill., Wis., Minn., Ia., Mo., Ala., Miss., S. D., Neb., Kan., Can.
Bignoniaceæ, Tecoma radicans (L.)—Ind., Ala., Miss.
Caprifoliaceæ, Lonicera Tartarica L.—Vt., Wis.
Caprifoliaceæ, Viburnum dentatum L.—Ind., Wis.

15. *Microsphæra Alni* var. *Vaccinii* (Schw.) Salm.
Erysiphe vaccinii Schw., 1834, as above, 1900.
Bignoniaceæ, Catalpa Catalpa (L.)—N. J., W. Va., O., Ill., Mo.
Bignoniaceæ, Catalpa speciosa Ward.—Ill., Ia., Neb.

16. *Microsphæra Alni* var. *Extensa* (C. & P.) Salm.
Microsphæra extensa C. & P., 1872, as above, 1900.
Fagaceæ, Quercus alba L.—Vt., N. J., Ind., Ill., Wis.
Fagaceæ, Quercus rubra L.—Vt., O., Ind., Ill., Wis., Ia., Ala.

17. *Microsphæra Grossulariæ* (Wallr.) Lev.
Alphitomorpha penicellata var. grossulariæ Wallr., 1819, as above, 1857.
Grossulariaceæ, Ribes Sp.—Cal.

18. *Microsphæra diffusa* C. & P. (1872).
Caprifoliaceæ, Symphoricarpos Symphoricarpus (L.)—Ind., Ill., Ia., Mo., Neb., Kan.

V. Erysiphe. *Hedwig* (1851).

19. *Erysiphe Polygoni* DC.
Mucor Erysiphe Linn., 1774, as above, 1805.
Magnoliaceæ, Liriodendron Tulipifera L.—N. Y., W. Va., O., Ind., Ill., Ala., Miss.
Papilionaceæ, Pisum sativum L.—Vt., Mass., N. Y., N. J., Ill., Ia., Mo., Ala., Miss., Cal.

20. *Erysiphe Cichoracearum* DC.
Mucor Erysiphe Leyss, 1783, as above, 1805.
Polemoniaceæ, Phlox divaricata L.—Wis.
Polemoniaceæ, Phlox Drummondii Hook.—N. J., Wis.
Polemoniaceæ, Phlox paniculata L.—Ind., Ill., Wis.
Polemoniaceæ, Phlox Sp.—N. J., O., Ill., Ala., Can.
Cucurbitaceæ, Cucumis sativus L.—Vt.
Cucurbitaceæ, Cucurbita Pepo L.—N. Y.
Cichoriaceæ, Tragopogon porrifolius L.—Neb.
Compositæ, Dahlia variabilis Desf.—O.
Compositæ, Helianthus annuus L.—Ind., Ala., Neb., Mont.
Compositæ, Helianthus Sp.—O., Ill., Ala., Miss., Dak.
Compositæ, Zinnia elegans Jacq.—Ind.

21. *Erysiphe graminis* DC. (1815).
Gramineæ, Agrostis alba L.—Ia.
Gramineæ, Poa pratensis L.—Vt., W. Va., O., Ind., Wis., Ia., Mo., Miss., S. D., Kan., Wyo.

VI. Phyllactinia. *Leveille* (1851).

22. *Phyllactinia corylea* (Pers.) Karst.
    Sclerotium Erysiphe var. corylea Pers., 1801, as above, 1885.
    Fagaceæ, Castanea dentata (Marsh.) W. Va., O.
    Fagaceæ, Fagus Americana Sweet.—Vt, O., Ala., Wis.
    Ulmaceæ, Ulmus Americana L.—Ill., S. C., Ala.
    Magnoliaceæ, Liriodendron Tulipifera L.—Ind., Ill., Ala.
    Celastraceæ, Celastrus scandens L.—Vt., Ind., Ill., Wis, S. D., Neb., Kan., Can.
    Oleaceæ, Fraxinus Americana L.—Ind., Can.
    Bignoniaceæ, Catalpa Catalpa (L.)—O., Ind., Ill.

The following is a preliminary list of the hosts of the powdery mildews selected from among the plants that are more or less under cultivation. The numeral following the name refers to the species of mildew in the preceding list of mildews:

Acer saccharinum L., 9.
Acer saccharum March, 9.
Æsculus glabra Willd., 11.
Æsculus Hippocastaneum L., 11.
Agrostis alba L., 21.
American Ivy, 8.
Ampelopsis quinquifolia Michx., 8.
Apple, 1, 2.
Ash, 22.
Aspen, 7.
Basswood, 12.
Beech, 14, 22.
Bittersweet, 22.
Black walnut, 14.
Buckeye, 11.
Burning Bush, 14.
Butternut, 14.
Buttonwood, 14.
Carya alba Nutt, 14.
Castanea dentata Marsh., 14, 22.
Castanea sativa Mill., 14.
Catalpa 15, 22.
Catalpa Catalpa (L.), 15, 22.
Catalpa speciosa Ward., 15.
Ceanothus Americana L., 14.
Celastrus scandens L., 22.
Cherry, 1.
Chestnut, 14, 22.
Chrysanthemum, 20 (?).
Cratægus, Sp., 1.
Cucumber, 20
Cucumis sativus L., 20.
Cucurbita Pepo L, 20.
Dahlia variabilis Desf., 20.
Elm, 10, 14, 22.
Euonymus atropurpurea Jacq., 14.
Fagus Americana Sweet, 14, 22.
Fragaria cult., 4.
Fraxinus Americana L., 22.
Gleditsia tricanthos (L.), 14
Gooseberry, 6.
Grape, 8.
Haw., 1.
Hawthorn, 1.
Helianthus annuus L, 20.
Helianthus sp., 20.
Hickory, 14.
Hicoria (Carya) alba (L.), 14.
Honey Locust, 14.
Honeysuckle, 14.
Hop, 3.
Horse-chestnut, 11.
Humulus Lupulus L., 3.
Ivy, 8.
Juglans cinerea L., 14.
Juglans nigra L., 14.
Kentucky blue grass, 21.
Lancewood, 14.
Lilac, 14.
Linden, 12.

The following papers have been consulted in the preparation of the last few paragraphs of this Bulletin:

Anderson, F. W., for Montana, Journal of Mycology, 1889.
Atkinson, G. F., for Alabama, Journal E. Mitchell Sci. Soc., 1891.
Bulletin Cornell Univ., 1897.
Bessey, C. E., for Iowa, Seventh Rep. Iowa Agr. College, 1877.
Burrill, T. J., for Illinois, Bulls. Ill. St. Lab, 1876 and 1887.
Ellis & Everharts N. A Pyrenomycites, 1892.
Classen, E., for Ohio, Fifth Rep. Ohio Cad Science.
Davis, J. J., for Wisconsin, Trans. Wis. Acad., 1893, 1903.
Earle, F. S., with Burrill, Tray and Underwood.
Farlow, W. G., for Massachusetts, Bulletin Bussey Institute, 1876.
with Seymour Host Index of Fungi of United States, 1888.

Gerard, W. R., for New York, Bull. Torr. Club 1873, 1875.
Harkness, H. W., for California, Bull. Calif. Acad. Sci., 1886.
with Moore Cat. Pacific Coast Fungi, 1880.
Harvey, F. L., for Maine, Bull. Torr. Club, 1896.
Hitchcock, A. S., for Iowa, Bull. Ia. Agr. College, 1887.
Howe, E. C, for New York, Bull. Torr. Club, 1874.
Jones, L. R., (with Orton) for Vermont, Rep. Vt. Exp. Sta, 1898, 1900.
Jones, M. E., for California, Pro. Calif. Acad. Sci., 1895.
Kellerman, W. A., (with Swingle) for Kansas, Jour. Myc., 1888.
Kelsey, F. D., for Montana, Bot. Gazette, 1889; Jour. Myc., 1889.
Millspaugh, C. F. (with Nuttall), for W. Virginia, Field Col. Mer. Pub., 1896.
Nelson, A., for Wyoming, Bull. Wyom. Exp. Sta., 1896.
Pammel, L. H., for Illinois and Iowa, Jour. Myc., 1888-1894.
Peck, C. H., for New York, An. Rep. N. Y. Mus. Nat. Herb., 1870-1902.
Rose, J. N., for Indiana, Bot. Gazette, 1886.
Selby, A. D., for Ohio, Bull. Ohio Agr. Exp. Sta. 3, 1893.
Salmon, E. S., for whole country, The Erysiphaceæ—Mem. Torr. Bot. Club, 1900.
Seymour, A. B., for Northwest, Pro. Bost. Soc. Nat. Hist., 1890.
Tracy, S. M. (with Earle), for Mississippi, Bull. Miss. Exp. Sta. 34, 1895.
(with Galloway), Jour. Myc., 1888.
Trelease, W., for Wisconsin, Trans. Wis. Acad. Sci., 1885.
Underwood, L. M. (with Earle), for Alabama, Bull. Ala. Agri. Exp. Sta., 1897.
Walters, L. A., for Kansas, Trans. Kan. Acad. Sci., 1896.

FUNGI AS RELATED TO WEATHER.

The following items concerning crop plants are gathered from the "Weather and Crop Bulletins," issued weekly by the State Weather Service during the months of April to September of the present year.

May 12th—"Pears dropping badly;" "Peaches dropping."

May 19th—"Clover curling badly on high land;" "Keiffer pears dropping;" "Clover wilting on high fields."

May 26th—"Wheat greatly affected by dry weather, and much has turned yellow;" "Clover wilting;" "Fruit dropping;" "Wheat in many places withering;" "Apples dropping badly;" "Wheat turning yellow;" "Tomato plants dying;" "Some wheat rusting."

June 2d—"Clover wilting;" "Clover wilting and dying out."

June 9th—"Rye filling fairly well, some rust;" "Potatoes wilting."

June 16th—"Early cherries ripe, but crop light, continuous rains during the week have caused them to crack and split;" "Much early-planted corn rotted in the ground."

June 23d—"Strawberries rotting on vines;" "Cherries rotting badly;" "Corn turning yellow;" "Wheat ripening fast, but rusting."

June 30th—"Corn turning yellow;" "Wheat badly curled;" "Leaf blight on apple trees and early tomatoes;" "Tomato blight observed in some fields."

July 7th—"Early tomatoes have blighted badly;" "Oats looks badly, much scald and rust noticed;" "Wheat somewhat crinkled."

July 14th—"Fruit dropping badly."

Juyl 21st—"Pears affected with blight;" "Plums rotting badly;" "Cantaloupes blight;" "Peaches poor and dropping;" "Late apples dropping;" "Early peaches and plums rotting badly."

August 4th—"Some fields of potatoes show blight and rot;" "Potatoes show signs of rot in low places;" "Potatoes rotting badly in low fields;" "Asparagus shows a little rust;" "In some fields the potatoes are rotting;" "Grapes in unsprayed vineyards begin to rot;" "Potatoes and summer apples abundant, but rot in former is serious;" "Some twig blight."

August 11th—"Potatoes are showing considerable blight;" "Potatoes rotting;" "Grapes showing some rot;" "Plums rotting badly;" "Some rot among potatoes;" "Potatoes rotting;" "Potatoes are rotting;" "Apples are dropping badly;" "Late tomatoes begin to blight, and the young watermelons are rotting on the vines;" "Much leaf-blight;" "Potato rot prevalent in low places."

August 18th—"Potatoes are rotting badly;" "Potatoes rotting badly;" "Potatoes and grapes rotting badly;" "Cucumber and melon vines blighted;" "Potatoes are rotting to some extent;" "Peaches rotting on the trees;" "Potatoes and corn scalding on low fields;" "Potatoes beginning to rot;" "Potato rot increasing in some places;" "Potatoes rotting badly in low fields;" "Lima beans are molding on the vines;" "Tomatoes are rotting;" "Tomatoes are affected by blight."

August 25th—"Melon, cucumber and pumpkin vines rotting on the ground;" "Potatoes rotting badly;" "Plums rotting somewhat;" "Potatoes injured by blight;" "Potatoes rotting badly;" "Potatoes rotting badly;" "Some rot in potatoes;" "In some patches potato vines are turning black;" "Potatoes, but little rot being noticed;" "Potatoes, average yield, but rotting on low ground;" "Lima beans molding;" "Potatoes rotted considerably;" "Lima beans rotting and millet rusting;" "Potatoes still rotting;" "Potatoes rotting con-

siderably;" "Potatoes rotting badly;" "Tomatoes are rotting;" "Grapes are rotting badly;" "Lima beans ruined by the white mold;" "Lima beans molding;" "Early potatoes a fine crop, no rot;" "Citron vines have a stunted appearance, rusty blight has begun its fatal attack in places;" "Potato rot severe in low fields;" "Peaches begin to rot and apples to drop badly;" "Melon and citron vines blighted."

September 1st—"Potatoes rotting badly;" "Whole fields of potatoes rotted;" "Much blight in potatoes;" "Potatoes fair where not blighted;" "Potatoes rotting;" "Potatoes have ceased rotting;" "Potatoes badly infested with rot;" "Keiffer pear trees leafless;" "Potatoes good, no serious rot noticed;" "Potatoes rotting badly;" "Potatoes rotting badly;" "Potatoes rotting badly;" "Grapes rotting;" "Lima beans molding;" "Potato rot reported in places;" "Blight and rot of various kinds quite prevalent;" "Potato rot increasing;" "Lower leaves of tomatoes have blighted;" "Tomatoes rot badly;" "Citron and melon vines nearly all dead and crop a failure;" "Tomatoes rotting."

September 9th—"Rot still continues serious in potatoes;" "Potatoes and tomatoes rotting badly;" "Tomatoes and potatoes continue rotting badly;" "Potatoes have ceased rotting;" "Lima beans badly mildewed" "Late potatoes rotting badly;" "Potatoes improving, only a little rot noticed;" "Grapes ripening rapidly, but rotting some;" "Late peaches rotting and cracking;" "Potatoes continue rotting;" "Grapes rotting;" "Potatoes blighting and rotting;" "Corn and tomatoes, some rot noticed;" "Potatoes still rotting;" "Lima beans utterly ruined by white mold;" "Potatoes rotting;" "Tomatoes rotting and blighting badly;" "Malignant potato rot interferes in many cases with reliable storage or shipment."

September 15th—"Potatoes rotting badly;" "Potatoes rotting badly;" "Potatoes a failure;" "Lima beans and late tomatoes a total failure;" "Tomatoes rotting badly;" "Potatoes in some fields rotted badly;" "Tomatoes rotting badly;" "Peaches rotting badly;" "Potato rot serious;" "Corn affected with blight;" "White potato rot decreasing;" "Tomatoes rotting badly;" "Tomatoes blighting and rotting on the vines;" "All melon and pickle vines destroyed;" "Tomatoes blighting badly;" "Watermelons a failure;" "Only a little asparagus rust observed;" "Winter apples dropping badly;" "Peaches a failure;" "All vine crops still rotting badly;" "Watermelons and

cantaloupes complete failure;" "Late pickles scalding;" "Second crop of potatoes, in most cases, will be a failure."

The crops mentioned in the above reports are here arranged alphabetically, thus showing the number of times a specific trouble is mentioned. The numeral in parentheses indicates the times the same disease is reported for the given date:

Apples.—May 26th, dropping. June 30th, leaf blight. July 21st, dropping. August 11th, dropping. August 25th, drop. September 15th, dropping.

Asparagus.—August 4th, rust. September 15th, rust.

Corn.—June 16th, rotted. June 23d, turning yellow. June 30th, turning yellow. August 18th, scalding. September 9th, rot. September 15th, blight.

Cantaloupes.—July 21st, blight.

Clover.—May 19th, curling; wilting (2). June 2d, wilting (2); dying out.

Cucumber.—August 18th, blighted. August 25th, rotting.

Citron.—August 25th, vines have a stunted appearance; blighted. September 1st, dead.

Cherries.—June 16th, crack and split. June 23d, rotting.

Grapes.—August 4th, rot. August 11th, rot. August 18th, rotting. August 25th, rotting. September 1st, rotting. September 9th, rotting (2).

Lima Beans.—August 18th, moulding. August 25th, moulding (2); rotting; white mold. September 1st, molding. September 9th, mildewed.

Millet.—August 25th, rusting.

Melon.—August 18th, blighted. August 25th, rotting; blighted. September 1st, dead.

Oats.—July 7th, scald and rust.

Plums.—July 21st, rotting (2). August 11th, rotting. August 25th, rotting.

Potatoes.—June 9th, wilting. August 4th, blight; rot (3); rotting (2). August 11th, blight; rotting (3); rot (2). August 18th, rotting (5); scalding; rot (2). August 25th, rotting (7); blight; rot (2); vines turning black; rotted. September 1st, rotting (5); rotted; blight; blighted; rot (3). September 9th, rot (2); rotting (7); blighting. September 15th, rotting (2); rotted; rot.

Pickles.—September 15th, scalding.

Peaches.—May 12th, dropping. July 21st, dropping; rotting. August 18th, rotting. August 25th, rot. September 9th, rotting and cracking. September 15th, rotting.

Pears.—May 12th, dropping. May 19th, Keiffer pears dropping. July 21st, blight. September 1st, Keiffer trees leafless.

Pumpkin.—August 25th, rotting.

Rye.—June 9th, some rust.

Strawberries.—June 23d, rotting.

Tomatoes.—May 26th, dying. June 30th, leaf blight; blight. July 7th, blighted. August 11th, blight. August 18th, rotting; blight. August 25th, rotting. September 1st, blighted; rot; rotting (2). September 9th, rot; rotting; blighting. September 15th, rotting (4); blighting (2).

Watermelons.—August 11th, rotting.

Wheat.—May 26th, turned yellow (2); withering; rusting. June 23d, rusting. June 30th, curled. July 7th, crinkled.

Mildew of Lima Beans.

A glance at the above reports of the crop correspondents shows that the mildew of the lima beans is common. This disease was considered at some length in the Report for last year (pages 399–403), where three engravings were given showing appearance and microscopic structure of the mildew. As the trouble is apparently upon the increase, the growers of lima beans may find the information in the Report for 1902 of some service. The Experiment Station also has a Bulletin (No. 151—"Bean Diseases and Their Remedies") that may be of service in fortifying against this enemy.

The writer was recently particularly impressed with the fact that the mildew was unusually abundant upon vines that were directly over a pile of shelled pods, many of them mildewed, that had been thrown there, instead of in an out of the way garbage barrel. The fungus is exceedingly contagious, and every effort should be made to remove the mildewed pods from the field, instead of taking them back again after they have been shelled.

Growers of lima beans may well make note of the susceptibility of varieties, with the hope of finding some sorts that are less subject to the disease than others. A study of the varieties of asparagus, with

regard to the rust, has been one of great profit, and the same kind of watchfulness may be exercised with all kinds of crops.

In closing it is remarked that the fungus in question of the lima beans is a mildew closely related with several others, as the ones upon lettuce, grape, onion, spinach, etc. It is well, therefore, to reserve the terms "blight," "rot," and even "mold," for other forms of fungi. Whenever any of the three last names are mentioned in connection with the lima beans, the trouble is more than likely the work of one and the same mildew.

The Rotting of Potatoes.

The rotting of potatoes was reported in the Weather and Crop Bulletins as early as August 4th, and for weeks the number of reports of potato rot increased. On August 18th the correspondents reported as follows: "Potatoes are rotting badly;" "Potatoes rotting in many fields;" "Potato rot increasing in some places." For August 25th and September 1st the common expression was "Potatoes are rotting badly."

The common field potato is troubled with a number of plant diseases, all of which may have had some part in the wholesale decay above indicated. An examination of the fields, however, leads to the opinion that the chief trouble has been the so-called potato rot. In 1889 there was a similar outbreak of this disease, and a leaflet (Special Bulletin *G*) was prepared and circulated among the potato growers. From it some of the facts connected with the potato rot are gathered.

This disease is caused by a fungus (*Phytophthora infestans* D By.) which is closely related to the downy mildew upon the grape. It first attacks the potato leaves, causing them to curl and become "frosty" upon the under side, after which they quickly turn brown and decay. From the leaves the fine threads of the fungus pass to the stems, and, if the conditions are favorable, the vines are soon dead and leafless. The potatoes are the last to be attacked, and, owing to their size and solidity, may be considerably infested internally with the fine filaments of the fungus before the condition familiarly known as the rot becomes evident. From this it follows that the loss from the decay of the tubers after harvesting the crop may possibly be more than that occurring in the field.

Conditions Favoring the Rot.—The first essential is abundant moisture. Since 1840, when it is thought that the trouble was intro-

duced into this country from South America, the wet years have been the seasons of most rot. A moist atmosphere favors the development of the fungus in the leaves and stems; the rains assist in conveying the germs (spores) from the foliage to the tubers, and the wet soil encourages the growth of the filaments that may have reached the potatoes by descending through the stems. A second favoring condition is warm weather—not hot or cold, but a condition of the atmosphere which obtains when there is a week or month of showery, summer weather, often spoken of as "close" or "muggy"—just such weather, in fact, as we have experienced throughout the State during August. A large quantity of decaying organic matter, as coarse barnyard manure, perhaps, stimulates the development of the rot, especially if accompanied by favorable conditions of temperature and miosture.

Treatment of Infested Fields.—It is evident that, after the vines have been killed, there can be no further growth of the tubers, and as the disease first attacks the leaves and tips of the vines and works downward towards, and finally into, the tubers, it follows that there can be no loss in yield, and a great possible gain in healthfulness, by early digging. As a rule, the potatoes should be removed from the soil as soon as possible after the vines have been "struck" by the rot. The dead vines abound in the spores of the disease, and it is possible for the tubers to be infested by contact with the vines at the time of digging. Therefore, it is an important and inexpensive precaution to rake the vines into heaps and burn them before the potatoes are dug, at the same time destroying millions of germs of the rot, some of which might otherwise do injury elsewhere.

Treatment of Harvested Tubers.—The same conditions favor the rot after as before digging, and, therefore, the dug tubers should be left to dry thoroughly, then the sound ones can be stored where they can be kept dry, cool and with a good circulation of fresh air. A damp, warm, close cellar favors the growth of the rot. Air-slaked lime, a handful or so per bushel, may be dusted over the freshly-harvested potatoes to destroy any adhering germs.

Preventive Measures.—The conditions which favor the rot are not under human control, but knowing the habits of the pest and that it does not usually make its appearance until midsummer, it follows that early varieties of potatoes, when planted early, will usually mature before the rot appears, and thus escape. It is also to be borne in mind that a loose, light soil does not promote the decay like a

clayey one, in which the water is held and air enters with difficulty. From the nature of the disease it is not expected that anyone would think of attempting a second crop upon an infected field until some years have elapsed. Probably much of the trouble arises from the seed not being free from the disease. If possible, the potatoes for planting should be obtained from a locality where rot has not prevailed. The tubers for seed may be soaked in a solution of bluestone (sulphate of copper) before planting. Some recommend placing the "seed" in an oven for a few moments, heated to near a hundred degrees. If possible, plant upon a naturally dry or well-drained soil, and hill up the earth well around the vines at the last plowing, thus giving a good covering to the potatoes and making it less easy for the germs to reach the tubers through the soil.

Historical.

Concerning the history of the disease above considered, Dr. Farlow* has written: "At times its advent is so sudden that within a few hours the potato fields change from green to brown and black, and the plants which in the morning gave promise of an abundant crop, before night might present a mass of decaying vegetation, in which are involved not only the leaves and stems, but also the tubers. The disease occurred in this violent form in 1842 and again in 1845, and spread over a good part of the United State and the British Provinces, and also destroyed the crop in Great Britain, Ireland, Belgium and parts of Germany and France. The greatest injury was done in Nova Scotia, New Brunswick and Ireland, owing to the fact that in these countries the potato was the principal crop. Since 1845 the disease has recurred, but never with such violence, although during the year 1874 the damage was considerable. Although public attention was first called to the rot in 1842, it is not likely that it then appeared for the first time, but we must suppose that some of the vaguely-described epidemics of the last century were of the same nature.

"It is with sudden and violent outbreaks, as those of 1842 and 1845, that in the public mind the potato rot is associated. As a rule, however, the disease is of a milder type."

Since 1889 there has been, in New Jersey, one very wet July, namely, in 1897, when the rainfall reached the total average for the

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*The Potato Rot—Bulletin of the Bussey Institution, Harvard University, 1875.

State of 11.42 inches. This is the heaviest precipitation for a single month during the fifteen years that the writer has been connected with the Experiment Station. While there were excessive rains in 1897, there were also periods of drought during the growing season. Thus a dry spell was broken by the heavy storms of July, and these, in turn, were followed by a dry September, with less than half of the average rainfall. The conditions for an outbreak of the potato rot fungi were not as favorable in 1897 as in 1889, when September had double its average rainfall. However, the reports of the crop correspondents show that there was considerable loss in the potato fields. It is probably true that a wet July is very favorable to the development of the potato rot, and when this is followed by large rainfalls in August and September the crop is quite certain to suffer.

In this report a table of the monthly rainfall since 1888 is published, together with the averages for each month and each year during the fifteen years.

The accompanying plate (No. XIV.) is from Professor Galloway's Report of Section of Vegetable Pathology, United States Department of Agriculture, for 1888, and the explanations below are from the same source:

Fig. 1. Section through a diseased leaf, showing the mycelium in the tissues and two external spore-bearing hyphæ projecting through a stoma.

Fig. 2. Conidia and conidiophores more enlarged The epidermis and stoma are shown in the surface view. (F. L. Schribner, del.)

Fig. 3. A series of drawings, representing successive stages in the development of a conidium: *a*, end of conidiophore slightly swollen; *b*, *c*, successive stages in growth of the conidium; *d*, the conidiophore has pushed on, leaving the conidium already formed, attached to an enlargement below the point, and has begun to form another conidium on the end; *e*, the first-formed conidium has fallen from the enlargement of the conidiophore at *g*, and the second conidium formed is in turn left behind by the growing conidiophore, which is, forming a third conidium at the end.

Fig. 4. Mycelium in the tissue of a potato tuber. (F. L. S., del.)

Fig. 5. Series of figures representing the germination of a conidium: *a*, mature conidium; *b*, same, after remaining some time in water, five vacuoles have made their appearance; *c*, the contents are segmented into five distinct parts, each of which is provided with a vacuole; *d*, the exospore has ruptured and the zoospores are in the act of escaping; *e*, free zoospore; *f*, same a little later the vacuoles have become smaller; *g*, same, still later, the cilia are gone and the zoospore has come to rest; *h*, beginning of germination; *i*, *k*, *l*, successive stages in the growth of the germ tube or first mycelium filament; *m*, entrance of germ tube into the leaf through a stoma.

Fig. 6. Section of leaf, showing the penetration of a germ tube into the epidermis through the cell wall.

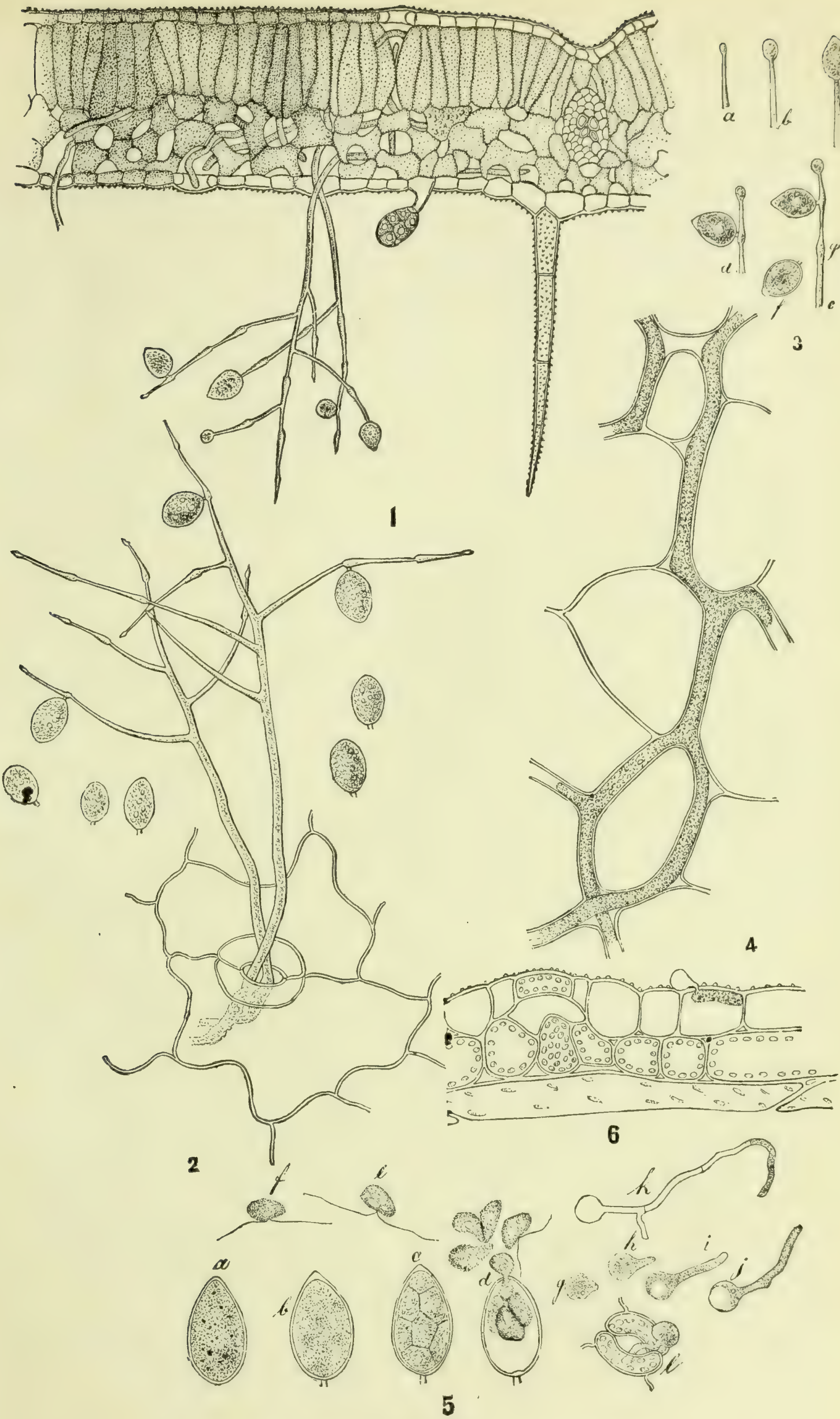

PLATE XIV.

The Potato Rot Fungus. Phytophthora Infestans D By.

[From Report U. S. Department of Agriculture.]

Diseases of Tomatoes.

From the above reports of crop correspondents concerning the condition of the tomato industry in the State during the past season it is evident that there has been much trouble with one of its leading truck crops. In fact, for some years past the growing of tomatoes has been attended with much anxiety, due to several causes, but chief among them are the various fungous enemies.

The subject of tomato growing, particularly that of its diseases, has been considered by this department, as a reference to the past reports will show, and it may be well to make a summary of the points that have been gained.

Tomoto Bacteriosis.—One of the most difficult diseases of the tomato for the trucker to contend with is the Bacteriosis, due to a microbe (*Bacillus Solanacearum* Sm.), which is often first recognized by a sudden wilting of the foliage, that soon changes to a yellowish-green and then to brown. Dr. E. F. Smith* has made a special study of this disease, and succeeded in inoculating the Jamestown weed, black nightshade, ground cherry and petunias, all of which belong to the tomato family of plants, with this wilt disease.

The disease is spread by means of the microscopic germs, and anything that opens up a passageway from the atmosphere to the tissue within will tend to develop the disease. Dr. Smith has been able to transmit the microbes from one plant to another by means of Colorado potato beetles, and determined the time of incubation to be from seven to nine days. Other insects, most likely, are active agents in the spread of this disease.

Concerning preventive measures, it is evident that the injuries from insects should be reduced to a minimum by using mixtures that will destroy these pests, and thereby preserve the skin of the tomato plant intact, thus destroying the carrier of the germs and keeping the natural barrier unbroken. When plants go down with this disease they should be burned, so that they may not remain as sources of the infection. As a further precaution, tomato growing should not be attempted continually upon any soil, and emphatically so when this disease is in evidence. Lastly, procure plants that are not likely to have been exposed to the Bacteriosis before being set in the field.

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*A Bacterial Disease of Tomato, Eggplant and Irish Potato. Bulletin 12, Division of Vegetable Pathology and Physiology, U. S. Department of Agriculture, 1896.

Tomato Leaf Spot.

Perhaps the most destructive fungous that preys upon the tomato is the leaf spot (*Septoria Lycopersici* Speg.), which is distinguished, first, by the small, oval spots it produces upon leaf and stem, followed by a dying of the foliage. A field of tomatoes badly affected with the Septoria will result in bare stems and small, stunted fruits. The leaf-spot fungus often attacks the plants before leaving the propagating beds and goes with the seedlings to their places in the field.

As precautionary measures it is well to use fresh soil for the seed beds—that is, earth that has not been exposed to the germs—and not set plants in ground where the disease prevailed the year before. When a field is badly affected all the dead and dying plants should be pulled up and burned, thus destroying millions of the active spores. The matter of spraying will be considered near the close of the paper.

Tomato Fruit Rot.

There are two leading fruit diseases of the tomato, namely, the Black Mold, caused by the fungus *Macrosporium Tomato* Ck. and the Tomato Anthracnose due to *Colletotrichum phomoides* Sacc.

Black Mold.—This trouble usually begins at the blossom end of the fruit, this being the weak point in fruits generally. In the case of the tomato this end is often brought against the earth, and this facilitates the entrance of the germs of decay into this imperfectly protected portion of the tomato. The remains of the flower may also remain and add to the ease with which a rot may gain a foothold. It is a fact that those varieties of tomatoes which are smooth-skinned and have no well-filled out and perfect blossom end are less likely to suffer from the Black Mold. It therefore follows that as a wise precaution any rough-skinned varieties with decidedly imperfect blossom ends should be discarded so far as avoiding the fruit rot is concerned. As a rule the smooth fruits are the ones that are preferred for the market and the table. The habit of the plant may have much to do with the amount of this fruit decay. Thus the "Trophy," with us, rots twice as badly as the "Dwarf Champion," and this is probably due to the more upright growth of the plants of the latter variety, thus tending to keep the fruits above the soil. The texture

of the fruit may have a decided influence, for it has been observed that the "Peach," a soft, flabby fruit, with rough skin, is much subject to decay. It is evident that something may be done to diminish the fruit rot in tomatoes by breeding and selecting for upright plants with smooth fruits, and it is hoped that some actual results may be recorded in coming reports.

Anthracnose.—This disease is most frequently met with upon maturing fruit, causing them to become sunken in minute saucer-shaped places that deepen and broaden until the whole fruit becomes a misshapen mass of decay. This disease is usually not as common as the black mold.

Experiments in Spraying Tomatoes.

Tests of fungicides for diseases of tomatoes were begun by this department in 1894, when a fifth of an acre of "Trophy" tomatoes was under treatment. It being the first season for this crop upon this portion of land, and possibly for climatic reasons also, there was very little of any of the various diseases that affected tomatoes. In 1895 the same land was continued in tomatoes and the diseases were still not at all prevalent. It is, however, recorded that the Bordeaux mixture reduced the decay of fruit to one-half that upon the untreated ground.

A third crop of tomatoes was grown upon the same soil in 1896, and there was a material increase of the leaf-blight, but the loss due to fruit rot was unimportant. Bordeaux and other fungicides, as soda bordeaux and potash bordeaux were effective in checking the diseases. It was also shown that land upon which old tomato plants had remained during the previous winter gave an increased amount of blight.

In 1897 tomatoes were again grown upon Plot II., Series III., for the fourth successive season; the record shows that during this year there was very little fruit rot, and the only leaf disease at all serious was the leaf-spot (*Septoria Lycopersici* Speg.), and this was kept under control by the frequent use of Bordeaux mixture and other fungicides.

During 1898 a half of Plot II., Series III., was kept in tomatoes for the fifth successive season, and it was shown that the total crop upon this land exceeded that of a corresponding number of the same varieties of plants upon an equal area that was new to tomatoes. The total weight of ripe marketable fruits upon the old land was 971.75

pounds and 740.50 upon the new land. This indicates that with the care taken to spray the vines, gather and destroy all decaying fruits and remove and burn the vines in the autumn, tomatoes have been grown upon the same land for five successive years without apparent disadvantage to the crop. The sprayings were upon June 1st, 24th, July 6th, 15th, 30th, August 8th, 25th, September 6th and 23d, nine applications in all.

The western half of Plot II., Series III., was set to tomatoes for the sixth successive time in 1899. A duplicate set of the above plants was grown upon land new to tomatoes and the yield of marketable fruits was somewhat greater upon the new than the old land, the total in pounds for the former being 1,429, and for the latter, 1,057 pounds. The results of the eleven sprayings were not striking, as the fruit rot and leaf diseases were but little in evidence. However, toward the close of the season the untreated plants were defoliated by a leaf mold (*Cladosporium fulvum* Cke.)

In 1900 the seventh successive crop was grown upon old tomato land and a duplicate set upon land new to the crop, with the result that there was a larger crop upon the new land, as the following figures for marketable fruits show: The total number of fruits upon the new land was 4,856, with a weight of 1,005 pounds, while the old land yielded 3,995 fruits, weighing 885 pounds, or a gain of 861 fruits and 120 pounds, respectively, in favor of the new land. This experiment of growing tomatoes for some years upon the same land indicates that with the precautions previously named, tomatoes may thrive upon the same land for a long time. There is, however, a falling off in the sixth and seventh seasons, as compared with duplicate sets of plants grown upon land where tomatoes possibly have never been set before. This success does not demonstrate that it is best, to keep land in tomatoes for general trucking, a rotation of crops should be maintained, but emphasizes the fact that comparative freedom from diseases may follow when care is exercised to keep the plants free from rotten fruit by removal of all decayed specimens and the thorough spraying of the vines with the Bordeaux mixture, beginning in May and continuing every two weeks through the growing season. The value of these sanitary measures has been so well demonstrated that while tomato growing has continued at the Experiment Area, it has been for the purpose of breeding with the hope of increasing the vigor and uprightness of the vine and reduce the seed and improve the quality of the fruits. Upon these points something is said, under the proper heading, elsewhere in this report.

Troubles of Tomatoes Under Glass.

Leaf Mold.—The chief fungous disease of greenhouse tomatoes is the leaf mold, due to the fungus *Cladosporium fulvum* Cke. This is quickly recognized by the pale, olive-colored, irregular patches upon the under side of the foliage, due to a felt of fungous threads and spores. Soon the infested areas become brown, and they are no longer of use to the plant. By means of the multitudes of active spores the mold quickly spreads, and the plants may be ruined. The fruits may be attacked by the same fungus, and undergo a rapid, noisome, watery decay.

In addition to the spraying recommended elsewhere (page 547) for outdoor tomatoes, it is necessary to have a good circulation of air. Many successful growers are impressed with the importance of training the plants high above the soil, even pruning away any branches that form near the benches.

Dropsy or Œdema.—Many greenhouse plants suffer from a disease which is not associated with any fungus, and appears to be entirely physiological. For example, the common geranium (Pelargonium) is frequently thus attacked, and the writer treated of this malady, with an engraving, in a previous report,* and within the past week the same trouble has been met with.

The first appearance of the trouble is the translucent dots, that may be best seen by holding the tomato leaf up against the light. This subject, in connection with the tomato, has been studied by Professor Atkinson,† and he concludes that the trouble is due to excess of water, favored by insufficient light—that is, a wet soil and a soil-temperature near that of the air. In short, the long nights, short days and cloudy weather of late winter induce the dropsical trouble, especially with a wet, warm soil, thus making root action excessive. The remedy, therefore, is to be found, as far as possible, in providing a cooler, dryer soil for the roots, with increased light for the stems and leaves.

In the winter of 1901–02 there was much of the Œdema in a lot of young tomato plants, in pots, that were standing upon a side shelf of the greenhouse and directly over a set of heating-pipes. The soil

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* Report of Botanical Department New Jersey Experiment Station for 1893, pages 432–433.

† Œdema of the Tomato, Bulletin 53, New York (Cornell) Experiment Station, May, 1893.

in the pots, by this means, was quite warm and kept wet by frequent watering. After the dropsy was manifest a majority of the pots were transferred to a middle bench, with no heating-pipes beneath, and the tomato plants here outgrew the trouble. Those left upon the side bench grew worse, and finally perished.

Diseases in the Pear Orchard.

The troubles in the pear orchard have been greater during the season than the reports of the crop correspondents would suggest. There are three leading fungous enemies of the pear, while there are several that play a secondary role in the shortening of the crop. The most conspicuous is the Fire Blight, which is an old and widespread disease, easily recognized by the brown, dead leaves clinging to dying branches in midsummer, giving the appearance of having been scorched by fire. Occasionally only one twig or large branch may be thus destroyed, but in its worst form the whole tree is stricken with the disease. The trouble is due to an invasion of microbes (*Bacillus amylovorus* Burl.), which multiply with great rapidity in the growing parts of the tree. These germs winter over in the twigs and ooze out through rifts in the bark in spring, and, the substance being attractive to insects, are carried by them to the opening buds and blossom when inoculation takes place, and the blight spreads down the growing twigs, causing the scorched appearance before mentioned.

Owing to the nature of the disease it is not easy to check with the ordinary spraying mixtures. Some varieties are less subject to fire blight than others, and this fact should be kept in mind in selecting trees for setting an orchard. When twigs are killed they are only sources of further infection, and should be removed and burned.

A second fungous enemy is the Leaf Blight (*Entomosporium maculatum* Sw.), and is one of the most common of the troubles of the pear orchard. It is this that has been actively at work this season in bringing about the loss of foliage to a large number of the pear trees of the State. As the common name indicates, this fungus produces a blight in the foliage, recognized at first by ashy spots in the leaves, followed by a premature falling to the ground, leaving the branches bare and the fruit to shrivel. This fungus has been controlled in many instances by spraying the trees with the Bordeaux

mixture. The writer has followed the trials in spraying, where the leaves were saved to the trees and the heavy crop of fruit matured handsomely by treating the orchard to cupram, which is a mixture consisting of—carbonate of copper, five ounces; strong ammonia, three quarts, and water, fifty gallons. This mixture has the advantage over the Bordeaux in being without lime and not coating the fruit seriously. Some pear growers use the Bordeaux for the first three sprayings, one before blossoming and two at intervals of about two weeks, afterwards, followed by the cupram as the fruit reaches larger size.

The third pear enemy is the Scab (*Fusicladium pirinum* Fcl.), which is easily mistaken for the leaf blight, just considered, but a close examination shows the spots upon the leaves to be more superficial. The fungus, by means of a network of fine, dark-brown threads, becomes fastened to the leaf and produces a patch, suggesting the common name of scab. It grows, also, upon the twigs, and frequently seriously defaces the fruit. When it attacks the young pear, just as the flower falls, a misshapen and worthless fruit is often the result. This fungus is very closely related to the one causing the scab upon apples, and should receive the same treatment, namely, at least three sprayings with Bordeaux mixture at intervals of about two weeks, beginning at the time the buds are opening, but not while the flowers are in bloom.

Aside from the fire blight, leaf blight and scab, above considered, there are other fungi that prey upon the pear, but these are the chief enemies to this crop. During this season there have been specimens of twigs and foliage sent to the Station that were almost black with a growth of various "soot fungi." These usually follow the injuries of insects, and the black coating often develops from the exudation produced by ants and other of the tribe. It is seen that, when a pear orchard suffers from a falling of its foliage, the trouble may be due to one or more of many causes. Any increase in the rainfall will usually be followed by a greater development of these enemies. As a general rule, in sections where pears are liable to suffer, it is well to anticipate the troubles by spraying the orchard early in the spring, as above indicated, and continue the applications throughout the season should the weather be favorable for the development of the diseases.

Temperature for Past Fifteen Years.

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Av'ge.
January	36.2	41.3	34.2	29.8	21.6	34.2	28.1	28.6	29.0	32.6	30.1	32.4	30.4	23.4	30.4	31.1
February	27.7	39.9	38.0	33.6	30.1	29.7	23.6	32.1	32.5	32.7	25.8	31.0	25.4	27.4	33.7	30.8
March	40.5	37.6	37.2	34.4	37.0	44.2	36.7	34.0	40.0	45.1	38.6	35.6	39.2	43.9	47.6	39.4
April	51.2	50.4	52.0	49.3	49.2	50.3	49.1	52.4	50.4	47.8	49.9	50.8	48.3	50.2	50.9	50.1
May	62.3	60.7	59.5	60.1	59.4	61.4	60.9	65.3	60.6	58.5	61.1	60.9	58.6	60.3	62.7	60.8
June	69.9	70.7	69.7	72.4	69.7	70.6	71.7	68.1	66.1	70.1	72.3	70.4	70.0	67.5	64.0	69.5
July	73.4	72.5	70.1	74.3	73.9	75.7	70.9	75.0	74.1	75.3	74.7	75.9	77.3	73.0	73.3	73.9
August	69.6	71.5	72.8	73.4	72.8	70.9	74.2	73.6	71.0	74.8	72.3	76.3	73.8	70.1	68.4	72.3
September	64.8	64.4	68.7	64.2	62.7	68.3	69.7	65.1	65.5	68.6	64.4	69.9	66.8	64.6	65.0	66.1
October	50.8	53.9	52.8	53.6	55.2	55.3	49.9	51.5	55.8	56.5	56.6	59.9	54.4	56.0	55.9	54.5
November	45.7	43.8	42.2	41.9	41.9	40.3	45.7	48.2	43.8	42.4	44.0	47.5	38.5	49.3	39.9	43.7
December	41.5	30.9	40.9	30.4	34.9	34.8	37.2	31.3	35.1	33.3	35.5	34.4	32.6	31.7	28.6	34.1
Average	52.8	53.1	53.2	51.7	50.7	52.9	51.5	52.1	51.9	53.1	52.1	53.7	51.3	51.9	51.7	52.2

Rainfall for Past Fifteen Years.

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	Av'ge.
January	5.68	2.29	6.57	5.15	3.04	2.34	4.66	1.66	2.80	4.20	4.01	3.85	2 52	3.28	3.90	3.73
February	2.49	4.17	5.11	1.63	5.73	4.42	1.28	6.77	3.61	3.48	6.06	5.30	0.94	6.24	4.87	4.14
March	3.79	6.08	5.06	4.75	3.73	1.77	3.16	5.34	2.87	3 33	6.54	3.51	4.64	4.34	5.13	4.26
April	5.32	2.65	2 19	2.49	5.21	3.09	4.88	1.35	3.79	3.74	1.73	2.29	6.31	3.62	3.97	3.50
May	4.09	4.24	2.97	5.04	4.07	7.72	2.85	3.21	5.68	7.00	1.92	4.71	5.60	2.04	0.59	4.11
June	3.73	3.59	2.92	3.85	2.95	2.28	3.24	5.46	3.38	2.10	2.50	3.08	1.57	6.57	7.68	3.66
July	10.19	5.62	5.30	4.03	2.72	1.66	4.26	5.50	11.42	4.96	5.75	4.74	5.87	4.78	5.51	5.49
August	5.18	4.90	5.32	3.63	6.52	2.58	2.53	1.83	4.39	5.36	4.36	2.68	9.43	3.91	6.95	4.63
September	8.36	4.75	2.46	1.81	3.30	7.46	1.07	4.37	1.65	2.00	5.88	2.86	3.38	5.65	3.34	3.88
October	3.80	6.33	3.44	0.52	4.22	5.67	3.66	2.24	2.43	5.76	2.72	3.70	1.93	6.39	8.92	4.11
November	8.48	0.82	2.39	7.29	3.48	3.34	3.17	3.05	4.59	6.76	2.29	3.43	2.38	2.20	1.26	3.66
December	1.62	3.89	4.25	1.87	3.39	4.36	2.61	1.43	4.90	3.53	2.11	2.59	7.30	7.23	4.08	3.68
Totals	62.73	49.33	47.98	42.06	48.26	44.69	37.37	42.21	51.42	52.22	45.87	42.74	51.87	56.25	56.20	48.73

Sunshine for the Past Fifteen Years in Percentage of Clear-Fair Days.

	1889. Per cent.	1890. Per cent.	1891. Per cent.	1892. Per cent.	1893. Per cent.	1894. Per cent.	1895. Per cent.	1896. Per cent.	1897. Per cent.	1898. Per cent.	1899. Per cent.	1900. Per cent.	1901. Per cent.	1902. Per cent.	1903. Per cent.	Av'ge. Per cent.
January	71	65	70	61	74	58	68	71	61	65	68	71	71	68	65	67.1
February	68	57	45	55	54	65	79	62	64	68	58	64	86	64	71	64.0
March	58	59	59	71	65	74	65	68	65	61	55	77	61	71	61	64.7
April	53	76	80	73	60	70	60	76	83	62	87	77	50	70	66	69.7
May	65	66	64	71	69	65	78	71	73	52	77	75	58	84	84	69.8
June	66	80	76	76	70	83	73	73	80	87	84	80	87	83	53	76.7
July	58	76	69	84	87	84	78	74	68	74	77	87	71	71	84	76.2
August	74	77	61	78	81	80	90	87	84	77	71	84	71	90	65	78.0
September	53	66	83	87	73	66	90	70	87	83	80	80	80	60	83	76.1
October	61	55	71	84	71	61	83	61	71	69	74	58	81	71	71	69.4
November	57	80	73	60	71	66	65	61	63	63	77	63	70	70	80	67.9
December	71	65	71	65	70	68	65	79	61	71	77	77	68	65	74	69.8
Average	62.9	68.5	68.5	72.1	70.4	70.0	74.5	71.1	72.1	69.4	73.7	73.6	71.2	72.3	71.5	70.8

REPORT OF THE ENTOMOLOGIST.

REPORT OF THE ENTOMOLOGIST.

JOHN B. SMITH, SC.D.

GENERAL REVIEW.

The work outlined for the season, after consultation with the Director, included—*first,* a study of the insects infesting the asparagus; *second,* a study of the injurious leaf-hoppers; *third,* the preparation of material for a general insecticide or "Spray" Bulletin.

The peculiar climatic conditions of the growing season produced a marked decrease in the insects troubling the asparagus, and it became impossible, as the summer advanced, to obtain a sufficient amount of the material needed for the experiments in contemplation. The collection of material for the study of leaf-hoppers was well under way when, in late April, the Laboratory building was in part destroyed by fire. The disarrangement thereby caused, the unsuitable quarters to which the work of the office was transferred and the destruction of a part of the apparatus made it so difficult to carry out the study needed that the idea of completing it during the current summer was abandoned. The collection of material has been continued, however, and a good series of some of the more common species has been accumulated.

The insecticide experiments were carried out, however, and the information obtained is in part presented here, and in part reserved for publication in bulletin form.

The depredations of certain birds on fruit farms and in gardens became so serious that a movement to remove all restrictions upon their destruction was promised. In order to get a clear idea of the actual state of affairs, and of the real position of these birds in the farm economy, as well as to prevent an indiscriminate attack upon the general scheme of bird protection, a study of the subject was made, limited, however, to New Jersey conditions. Some of the conclusions reached and the remedies suggested are presented in another part of this report.

Plant Lice.

A marked feature of the season was the abundance of certain forms of plant lice; some of them common enough annually, some not so usually seen.

The *Maple Louse,* a species of *Chaitophorus,* is always more or less abundant early in the season on the under sides of the leaves of Norway maples, but it usually disappears with the first spell of hot, dry weather. This year the weather combination suited the aphids most excellently well, and many trees were so much drained that they lost a large percentage of their foliage before midsummer. A letter from Mount Holly exemplifies this: "I have a luxuriant Norway maple, thirty feet spread of branches, in whose growth we took a great pride. It is being rapidly defoliated by the lice, and the limbs are dying as a result." At Vineland the soft maple was attacked by a species that made the ground under it a light blue color. At Montclair the varnished appearance of the leaves, due to the honey dew, attracted attention as the leaves fell. By the end of June the same story came from all sections of the State, and even those who knew of the ordinary annual course became afraid. A correspondent from Moorestown, after recounting the observations of previous years, adds: "Where they [the leaves] first began to drop, we sprayed with kerosene emulsion, as in other seasons, but it is very difficult to be thorough in such dense trees. When we gathered the leaves they were covered with lice; even the stems."

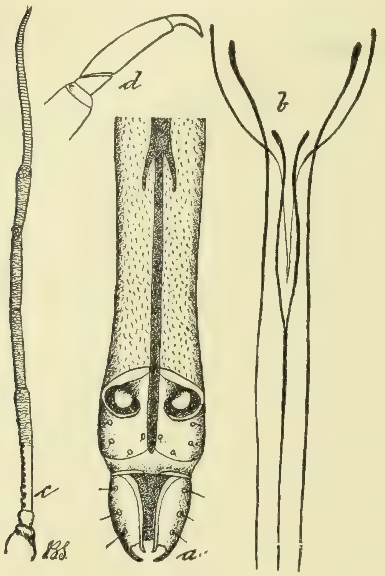

Fig. 1.
a, beak of plant louse; *b*, the lancets that lie within it.

Practically there is very little to be done as against these insects when weather conditions are so greatly in their favor. The application of insecticides on a large tree is a difficult task at best, and when

it must be a contact poison to reach plant lice on the under side of foliage as dense as that of the Norway maple it is almost a hopeless one. The life cycle of the species has not been completely worked out, so far as I know, hence it is not possible to say whether there is any especially vulnerable point where we can hope to strike with good effect. At present we can merely await a change in the weather with what philosophy we may.

On *Tulip Trees, Aphids* were troublesome only in the southern part of the State, though they were not by any means absent in the northern. What was said of the previous species applies here with almost equal force, and we are really quite as helpless.

Pine Trees are not often seriously affected by Aphids, hence it was rather unusual to receive a box containing specimens of a very large, blackish louse—a species of *Lachnus*—with word that on May 10th "the ground around the tree was entirely covered with them for six or eight inches away and three or four deep, all heading for the tree trunk, which was lined with a stream of them. They were apparently climbing up the tree and falling down again for amusement. Fortunately this infestation caused no apparent harm, and did not last long."

Scotch pine and Norway spruce, in nurseries, were also attacked by other species, and their growth was checked—a serious matter to the nurseryman who sells stock, which was thereby much impaired in value. Some attempts were made to control this insect with whale-oil soapsuds, but results were not very satisfactory, since strong mixtures could not be risked without endangering the trees.

On *Linden* I noticed at several points great masses of a *Lachnus,* a species as large as, and allied to, the one found on pine. The infested twigs were nearly always dying; but fortunately the infestation, though much greater than usual, was not general enough to endanger the trees.

Other shade and ornamental trees and shrubs became very lousy in early summer, and it was almost impossible, for a time, to find any plants that were not infested.

Rose Lice were abundant in gardens throughout the State, and numerous letters of inquiry reached the office. I have found that this insect succumbs very readily to tobacco extracts and decoctions, and have advised these almost uniformly. Attempts to control it with Paris green have resulted disastrously—primarily to the plant,

as a result, to the insect also. Arsenate of lead proved harmless to both plants and insects; but, incidentally, did some good by killing slugs, which were also plentiful.

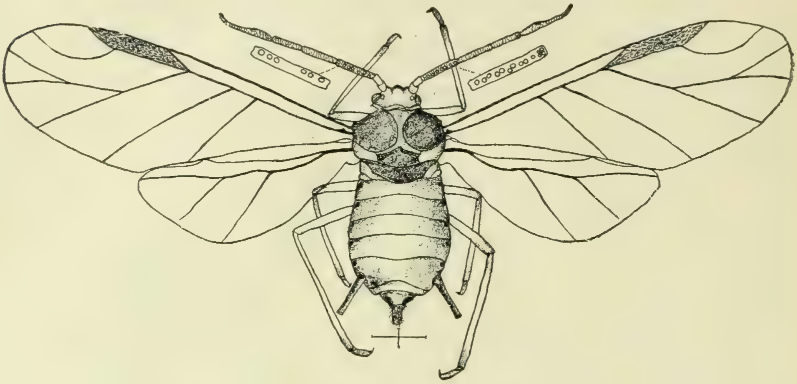

Fig. 2.
The apple louse: winged form.

Among the species attacking fruit trees none was more abundant than the *apple louse,* which, throughout June and in early July, was abundant in all sections of the State. Samples showing the tips of curled leaves or shoots black with soot fungus for a time came in almost every mail, and serious injury was caused without question in a number of instances. Some trees were actually killed, but more were stunted and retarded in growth. On an old tree this is not so perceptible, nor, perhaps, so important; but in an orchard of young trees it is a serious matter, and the check may require more than a year for its removal, especially if the feeding capacity of the bark in the infested shoots has been in any way impaired. I have nothing much to add to the recommendations made in Bulletin No. 143, in which I gave the life history of the species in detail. It is still as important as ever to attack the species in the early stages, before it gets much of a start, and fish or whale-oil soap is yet the most practical insecticide.

Pear Plant Lice have been noticeably abundant and somewhat injurious for the first time in my experience, and Keiffer was the victim in most instances, though Lawrence was a good second. I noted the insect in the Experiment Orchard, where it did very little real injury, and I doubt whether there was more than a local bad effect from their feeding.

Cherry Lice were plentiful in South Jersey, though, also, somewhat local in distribution, and there is no doubt that many trees rest exactly where they were when they first came into full foliage. Where a shoot once becomes curled up into a knot at its tip, it is usually at the end of its work for the season, and does not do very much the year following. Cherry lice are more difficult to kill than those infesting either apple or pear, and need a thorough drenching with strong whale-oil soapsuds or a mechanical mixture of oil and water. The drench must come in a fine, forcible spray, and not in a mass of coarse drops, or even a solid jet. The insects shed moisture, and the larger the drops the more completely they are protected. It is the fine, penetrating mist that covers and gets into their spiracles.

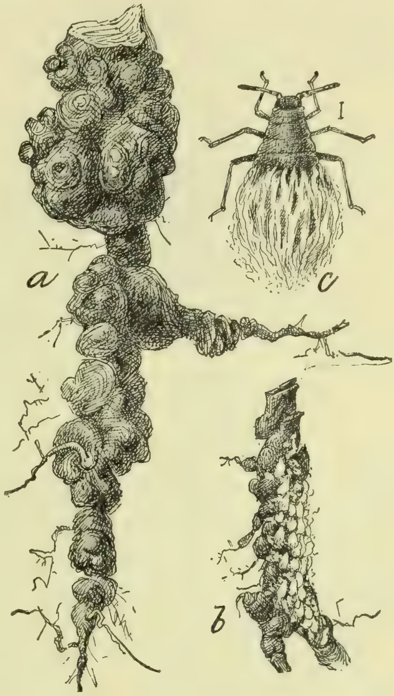

Fig. 3.

The woolly apple louse: injury to the roots is shown at *a*; at *b* is a cluster of lice on the roots, natural size; *c*, adult, wingless form, much enlarged. From Marlatt, U. S. Dept. Agl.

The Black Peach Louse came from several points in South Jersey, notably Atlantic and Gloucester counties, and always from young orchards. As the leaf-feeding form of this species is really the least important, and that infesting the roots is the most dangerous, the indicated practice is to use the salty fertilizers in excess, or to work in tobacco dust, in large doses, over the root system. Any practice that covers the ground, like a sod of crimson clover, is good, because it makes it more difficult for the lice to get to the peach roots. The more vigorous the tree, and the heavier the soil, the fewer will be the black peach lice.

The *Green Peach Louse* was locally common early in the season, but it did little more than curl up some of the old foliage, without interfering with the growth of the new shoots at the tips.

The injury caused on fruit trees is not all direct, nor all immediate. Almost any vigorous tree could well afford to lose all the sap that all the plant lice infesting it during the season might need.

Fig. 4.
Black peach louse: winged form.

But that is not the actual measure of damage. The plant lice, wherever they puncture, cause an abnormal condition. They introduce a salivary secretion where they puncture, and that kills—fast or slowly, as the case may be. Besides, wherever they attack a plant—that is, actually suck the plant juices—they cause, also, a modification of the tissue; the growth ceases, there is a hardening or degeneration of the surface, and in other ways the circulation is interfered with. So, when the season is done, there is not only the injury due to the direct withdrawal of sap, but also that which comes from the check in growth and loss to the conducting power of the plant tissue.

The grape louse (*Siphonophora viticola*) was more abundant and widely distributed than ever before in my experience. It made its appearance soon after the vines had made a good start, and clustered in quantities at the extreme tips. As a matter of experiment I snipped off the infested ends from one or two of my own vines, long before there was any idea that the infestation would prove to be in any way serious. On the others the insects were allowed to develop unchecked, and they soon extended back along the shoots on the leaves and even fruit-clusters. Then questions began to come in, and when I found that cutting off the tips had ended the attack on the vines so treated, I recommended that procedure where it could yet be carried out. In my own garden the insects, even where left unchecked, did not affect the fruit crop; but other localities did not get off so well, and some record "complete destruction" of blossom clusters and recent sets.

Late peas were again badly infested by plant lice; but the growers for canneries now force their crop along so as to get a full supply of

Fig. 5.
The pea louse: winged form. From circular of the Md. State Hort. Dept.

the earlier varieties, abandoning the late kinds altogether. It has made necessary some rearrangement of machinery to handle the product more promptly, but this has, on the whole, seemed preferable.

Scale Insects.

The *San José, pernicious, asiatic or chinese scale* is still the insect intended when the "the scale" is referred to. It is yet the most injurious of all our fruit insects and requires more time than all the other species combined. Nothing of consequence has been added to our knowledge of its life history, and the observations made have been rather in the direction of determining the effect of insecticides upon it. Its distribution and the efforts to prevent its further dissemination on nursery stock belong to the report of the State Entomologist, but the record of the attempted introduction of the Asiatic lady-bird beetle is given elsewhere in this report.

There are few localities now where there is not some of this scale to be found, though there are many orchards of considerable extent that are yet entirely free. The insect is forcing itself upon the atten-

tion of those who in the past have doubted its destructiveness, and, as the result of the general awakening, it is a fair conclusion that the day of worst injury is over. Our best orchardists who grow the great-

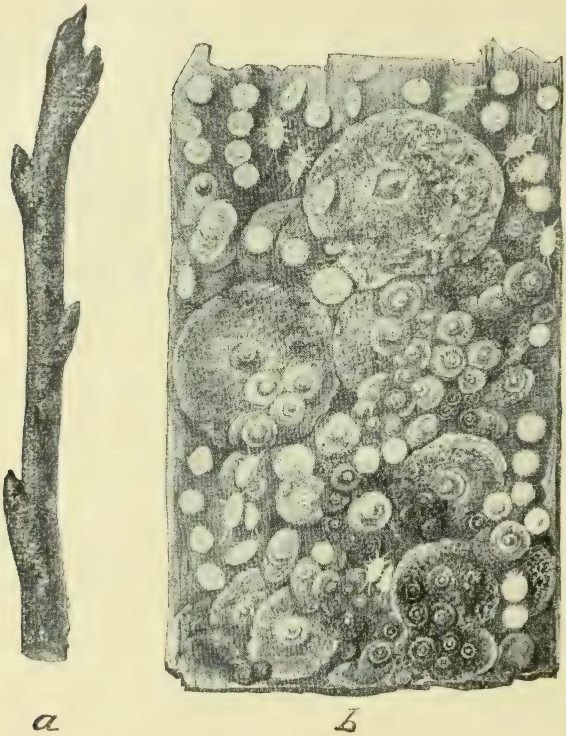

Fig. 6.

San José scale: *a*, on a twig, natural size; *b*, as seen under a lens, much enlarged. Howard & Marlatt, U. S. Dept. Agl.

est amount of fruit have all learned how to manage it, and the sufferers now are those who do not wish to go to any trouble to obtain their crop.

Fears have been expressed that the insect would get into the forests and on the wild plants of the roadsides, so that in time no locality could maintain an exemption; but this fear seems groundless. I have examined forest trees of many kinds, adjacent to infested orchards, and while I have found an occasional scale, have never found any infestation.

Oak, hickory, chestnut and American or European walnut, in the nursery rows, do not become scaly at all, or only slightly so. Chestnuts exposed to direct infestation for several years never had more than a few examples, which became half-grown and then died. Japanese walnuts may become considerably infested, but even here I never saw any very bad examples or infestation enough to hurt anything. The older and larger the trees the slighter the infestation found.

Sour gum, among the forest trees, is an exception to the rule. I have not found infested trees myself, but am informed by those that have seen it that it is as susceptible as peach.

Few of our shade trees are really troubled, except the European elm. Poplar, maples (except silver), tulip trees, linden, American elm and sweet gum all seem practically exempt. Silver maples become well infested sometimes, and while I do not believe that trees of any size would succumb to the insect or even suffer seriously, they might easily become the means of introducing it into a new locality.

Willows as a whole are susceptible, but to a variable degree. The Kilmarnock and laurel-leafed varieties are particularly troubled, and sometimes die under the attack. None of the other forms are so badly affected.

The European elm may become entirely coated, and I have seen one tree dying off as the result of the injuries caused. The American varieties are, if not exempt, at least not susceptible, and I have never seen more than an occasional scale where the surroundings were particularly bad.

Among the fruit trees, quince is measurably exempt. I have kept infested stock under observation for three years, and, while no insecticide applications of any kind were made, the trees were as scantily set in 1903 as they were in 1900. I have seen considerable scale on quince, but never enough to hurt the tree.

Certain varieties of cherries are clean, and the sour varieties are those most likely to carry the insect.

Other orchard fruits vary much in susceptibility, so that some varieties need watching much more closely than others—*e. g.*, in pears, the Chinese types, like Keiffer and Le Conte, need little attention, as compared with Lawrence, Bartlett or Seckel. On this point the records of the Experiment Orchard can be profitably compared.

Fig. 7.
A branch infested by San José scale which is diseased. The light rings around the edges of the scales show the fruiting processes of the fungus *Sphærostilbe coccophila*

An interesting occurrence was the discovery at Elberon of a series of infested plum trees, on which the scales were attacked by the disease fungus, *Sphærostilbe coccophila*. This is the same disease that I attempted to introduce some years ago into infested Burlington county orchards, but which failed to check scale development under our conditions. Just how the fungus came here I could not ascertain definitely, but I believe the trees were from the South and were scaly when received. If that is so, it is quite likely that the fungus was brought in as well. This suggestion is borne out by the fact that no trace of the disease could be seen on adjacent infested peach trees. It was instructive to note that on the trees where the fungus showed most abundantly there were moving larvæ and recent sets in great numbers.

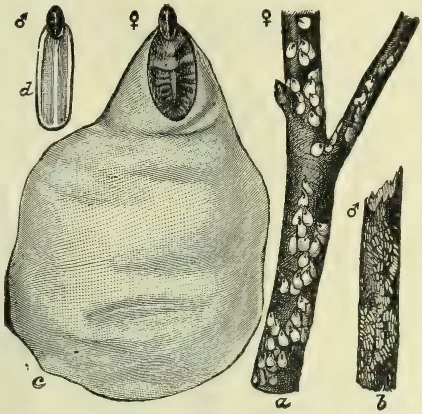

Fig. 8.
The scurfy scale: *a*, twig showing female scales; *b*, same, with male scales; *c*, female scale enlarged; *d*, male scale enlarged. From Howard, U. S. Dept. Agl.

The *Scurfy Scale* has been unusually plentiful during the season of 1903, especially on pear. I have quite frequently received it with a query as to whether it was not the pernicious scale, and have seen trees of considerable size well plastered up with it. Nursery trees have been badly hit in some instances, but this was usually in left-overs received from the North. Both apple and pear, grown in New York State, are much more frequently infested by this species than those grown in New Jersey. Where it is really plentiful, this insect is capable of causing, proportionately, an even greater check to growth than the pernicious scale, though it rarely kills, as the latter does.

The *Oyster shell scale* has been less troublesome than common, even on plants like the lilac, which are often badly infested. There has been quite an unusual amount of parasitism, indicated by the little round holes in the scales on infested trees.

The *Rose scale* was very abundant locally on raspberry and dewberry, but it seems to have been less common on blackberry than in previous seasons. Some of the dewberry cuttings sent in were pretty

well coated by the insect, and some of the raspberry plants were whiter than they should be for best results. There is nothing to add to the recommendations made in Bulletin No. 159, which deals specifically with this form. It is probable that some of the spread is due to infested plants sent out from nurseries, and growers should see that they get clean stock, even though the insect is not really a dangerously injurious one.

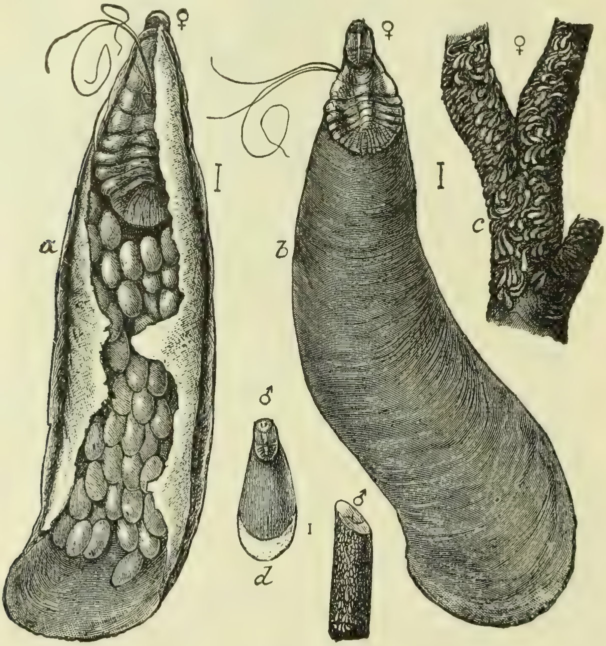

Fig. 9.

The oyster-shell bark-louse: *a*, female scale from below, filled with eggs; *b*, same from above, both enlarged; *c*, twig with female scales, natural size; *d*, male scale enlarged; *e*, same on twig, natural size. From Howard, U. S. Dept. Agl.

The cottony Maple scale has been sent in more frequently than for several years past, and not only from the shade trees, but as infesting grape and Virginia creeper. Bergen, Essex, Passaic, Somerset, Monmouth and Salem county localities were represented in the specimens actually sent in, and I heard of it in other ways from practically every section of the State. The scale is a very conspicuous one and looks dangerous, but the actual amount of injury caused is not very great. Occasionally, when a twig or branch is very densely covered, it may die, but this is the exception. Nor, as a rule, is the insect conspicuous two or more years in succession. It has so many natural

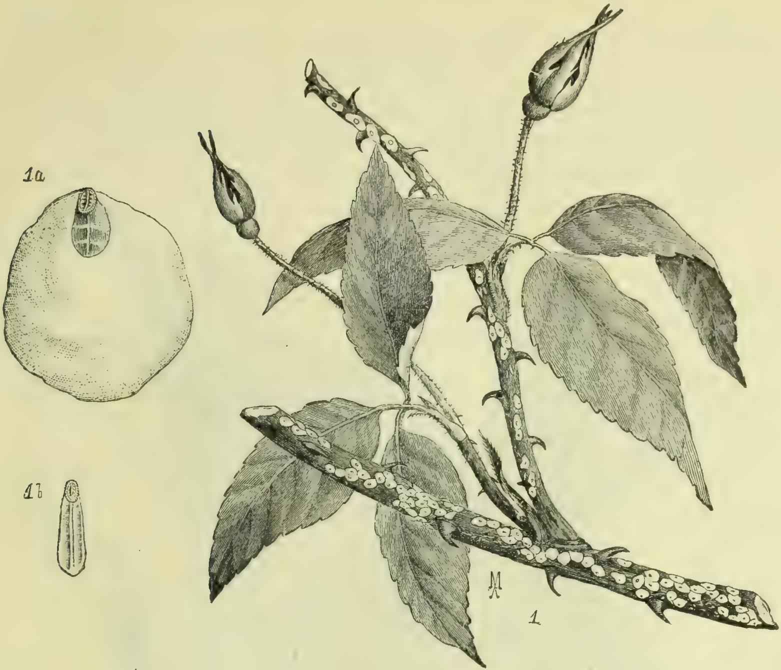

Fig. 10.

The rose scale: female enlarged at *a*; male at *b*. From Div. Ent., U. S. Dept. Agl.

Fig. 11.

The cottony maple scales: *Pulvinaria acericola* at *a* on the leaf; *P. innumerabilis* at *b* on a twig. From Howard, U. S. Dept. Agl.

enemies that, though its rate of increase is almost incredible, it is barely able to maintain itself. Insecticides are not indicated. Sometimes it may be advisable to cut out an unusually infested twig on maple or a shoot on grape, but ordinarily the native checks may be trusted to control the pest.

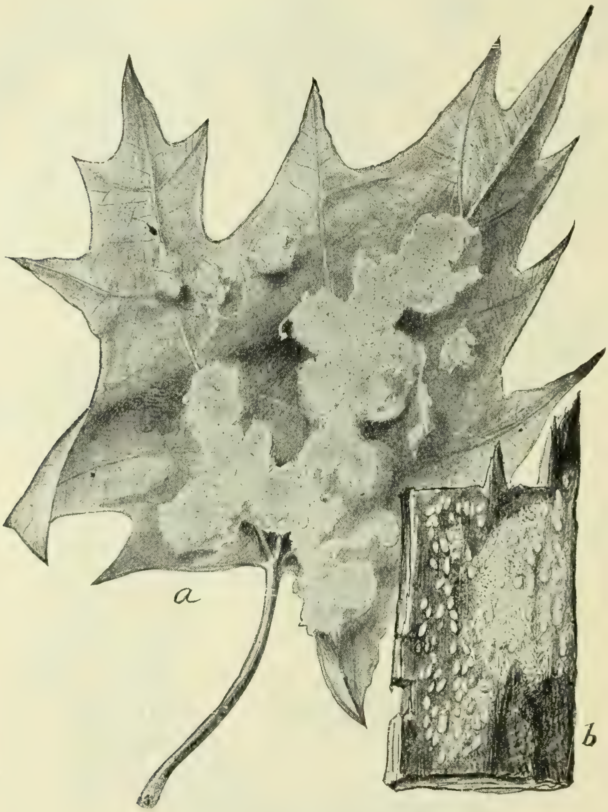

Fig. 12.
Pseudococcus aceris: a, the cottony masses covering adult females on leaf; *b*, young males and females on bark. From Howard, U. S. Dept Agl.

Pseudococcus aceris is another scale-like insect, with a white, waxy secretion, which spreads out from the body like a tuft of cotton. It forms masses on the bark of the trunk, and sometimes whitens them as if by a driving, moist snow. It also gets on the under side of the leaves and forms tuft-like masses that may be scattered throughout the tree. It gives the trees a rather curious appearance, but I have never been able to find that it did any real harm. The infestation

ranged from Hackensack to Cape May Court House, and was quite obvious on the trees at New Brunswick.

Where city trees are infested, and water pressure is available, nothing is much better than to turn a sold jet of water upon the masses at as close range as is comfortable. The insects are soft and crush easily, while the water washes out every crevice in which the males may seek shelter.

In connection with this species, the periodic appearance of the tree doctor was noted as follows: "A fellow has been around claiming to cure the trouble. He takes off the rough bark to the limbs, nearly to the inner bark, and then paints the trunk for about eighteen inches from the ground with something that looks like tomato soup. I don't see how this is going to clear out the woolly patches all over the top, and think he must be a grand humbug. I believe he claims that the stuff he puts on works into the sap and poisons anything that eats the tree. Two or three people have had him doctor their trees, but most of them gave him the cold shoulder."

The idea of poisoning the sap of a tree to kill the insects feeding on the foliage, while at the same time not harming the tree itself, seems to possess a curiously plausible fascination, and finds ever new believers. It seems not to be realized—*first,* what an enormous amount of material would have to be absorbed to be distributed in effective quantity to the foliage, and *second,* how sensitive a tree is to abnormal substances or even abnormal amounts of a normal plant-food.

Tulip Scales continue to cause trouble almost wherever this tree is grown, and practical treatment of single large trees is difficult, without an outfit such as the ordinary townsman does not have. This insect is about the only drawback to an otherwise ideal shade and ornamental tree.

Spraying for Hire.

In this connection, that of scale insects that infest shade and ornamental trees and, indeed, the fruit stock in town and village gardens, it may be well to mention that a very distinct demand has developed for someone that will spray or otherwise treat infested stock. In dozens of towns, large and small, within a distance of thirty miles from New York and Philadelphia, there are gardens of some kind about the majority of the houses. For some there is only a small lawn, with a shrub or two, and a little kitchen garden annex; for others there are extensive grounds, formally laid out with fruit trees,

small fruits and ornamental trees or shrubs—and much of it all infested by the pernicious and other scales, in addition to the less destructive pests. The owners of these plants wish to keep up their gardens and to destroy the insects, but the idea of a spray-pump and of insecticides and all that pertains to them frightens them off. Yet many of them would willingly pay a fair price to have their plants treated. In places like Montclair, Plainfield, the Oranges, Merchantville, Haddonfield or the like, it would be possible for an intelligent man, with a good outfit, to get quite a clientele. In some localities improvement societies are actually seeking men to undertake such a task.

The basis of pay would probably have to be based, as in the Pacific Coast States, where commercial spraying is well established, upon the amount of mixture applied, rather than the number of plants treated.

Leaf Hoppers.

The actual amount of injury caused by these insects is hardly appreciated, because they rarely kill the plants that they attack. The commonest example of their work is on the grape, where the foliage

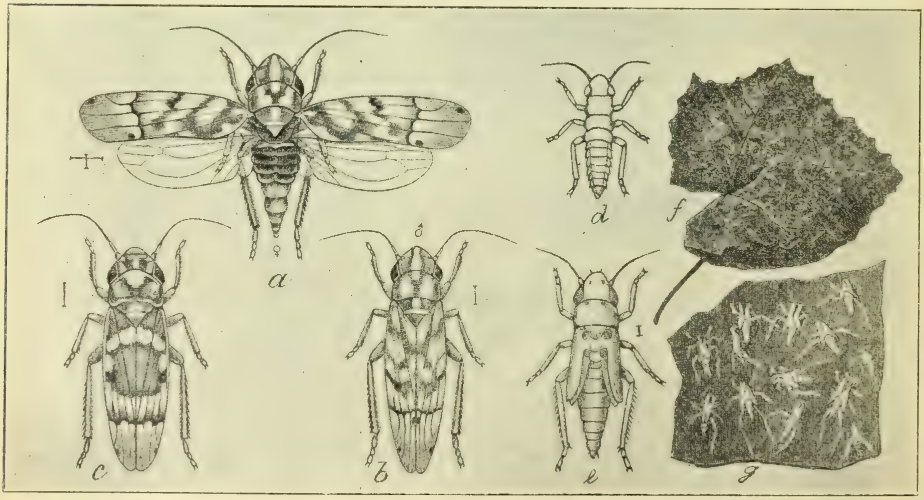

Fig. 13.

The grape-leaf hopper: *a*, adult with expanded wings; *b*, *c*, same, with wings folded as at rest, variations; *d*, young larva; *e*, pupa; *f*, an injured leaf; *g*, the cast skins left by the nymphs on the under side of the leaves. From Marlatt, U. S. Dept. Agl.

becomes spotted, brown and dry long before the fruit ripens, and hangs on, a picture of death, while it should be yet green and sappy. On such vines the grapes often ripen prematurely, before they attain full size, and the bunches are dead and withered in appearance, instead of plump and full of juice.

On the apple, and especially on young trees, hoppers are often numerous enough to affect the health of the tree very materially. The leaves become yellow spotted, and gradually are all yellow and lifeless before the wood has attained its full maturity, or the fruit and other buds have attained the necessary development for the year following.

Their injury is done entirely by puncturing the leaf tissue, usually from the under side, and sucking out the contents of the punctured cells. Where this has been done the tissue is dead, and a yellow or brown spot remains. As the insects are active, they move from place to place, and there is a scattering of such spots, which become grouped when they run into each other, and a yellow or brown blotch develops. The ribs or veins of the leaves are also punctured, and become dry and hard, incapable of carrying the plant juices. The net result is that the foliage does no more than half the work expected of it, and the plant suffers by just that much. But as no foliage is actually devoured, and no branches actually die off, this damage is not apparent.

As to remedial measures, these lie, at present, in the application of contact insecticides, and are not entirely satisfactory. The insects are so active that they get out of the way as soon as the applications reach the tree, and, unless they are hit in the air, a large proportion are almost certain to escape. It is necessary, therefore, to get to work before many of the insects are winged, and to envelop the tree in a cloud of spray, that they may be hit while trying to escape.

Lady-Birds.

The little predatory beetles of the family *Coccinellidæ,* commonly known as "lady-birds," should be familiar to everybody, yet it seems as if the commonest of all our species—the little, two-spotted species—was not sufficiently well known to save it from unmerited suspicion. Several times in late fall specimens were sent in to me with the ques-

tion whether these were not the carpet beetles. The truth is that plant lice were so plentiful this year (1903) that their enemies also increased, and this little, very convex, almost hemispherical beetle, with its red wing covers, each bearing a black spot, was not the least

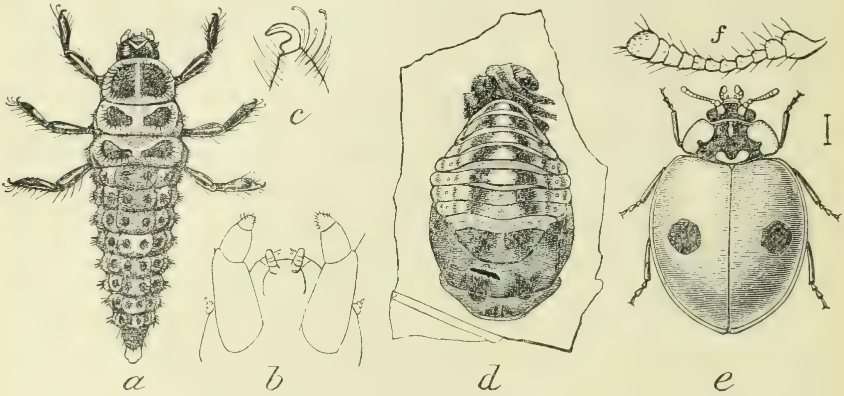

Fig. 14.
The two-spotted lady-bird, *Adalia bipuncta*: *a*, larva; *b*, *c*, structural details; *d*, pupa; *e*, adult. From Marlatt, U. S. Dept. Agl.

of these enemies. The adults live through the winter in any shelter they can find, and our little two-spotted friend prefers indoors to outdoors for a hiding-place.

The *twice-stabbed Lady-bird,* which is very similar in appearance to the Asiatic species recently introduced, and of which we had hoped

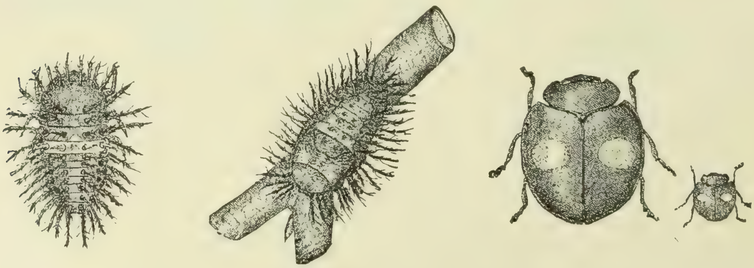

Fig. 15.
The twice-stabbed lady-bird, *Chilocorus bivulnerus*; larva, pupa and adult. From Comstock, U. S. Dept. Agl.

that it would render material assistance in controlling the pernicious scale, was much less abundant than usual, and, in fact, not much in evidence at any time during the summer. This fact was noted by

others, and a correspondent wrote me in August: "For several years the so-called twice-stabbed lady-bird has been on the increase on our young apple and plum trees; this season I have been unable to locate a single specimen. * * *" It is this periodical disappearance of the native species that made it desirable to supplement it with the Oriental species. Concerning the latter there is a record further on in this report.

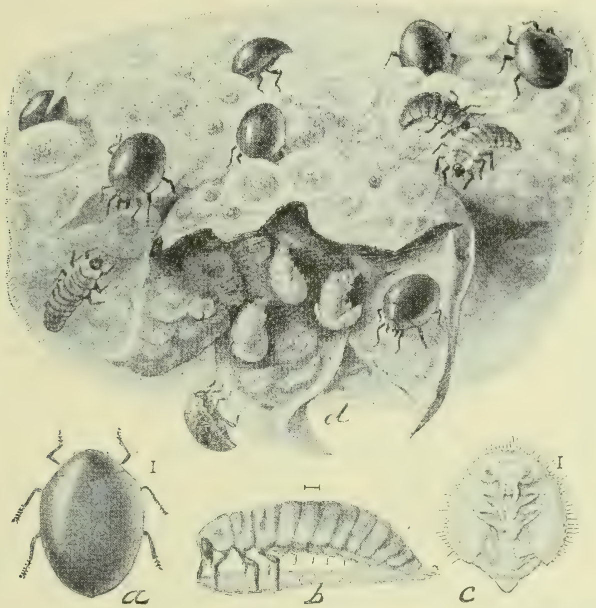

Fig. 16.

Pentilia misella: *a*, adult beetle; *b*, its larva; *c*, pupa; *d*, larvæ and adults feeding on the San José scale at the calyx end of a pear—all enlarged.
From Howard & Marlatt, U. S. Dept. Agl.

This little, black *Pentilia misella*, not larger than a pin-head, was very abundant late in fall, but not more so than I have seen it in previous years. It is a great feeder on the pernicious scales, and may be found on the infested trees all winter, but something happens to it each spring, when the hibernating forms scatter. It disappears almost completely until early fall, and is then again as abundant as during the previous year, and in the same way.

Codling Moth.

There was less of this pest than usual, and the species would hardly deserve mention here were it not that one of our most extensive apple growers tried the effect of banding the trees to trap the larvæ of the summer brood with such good results that he expects to continue the practice. This grower not only sprays, but sprays thoroughly, early in the season, yet a few specimens always escape and produce adults for a partial second brood, which attacks the fruits where they touch, and causes injury not reached by ordinary spraying. In fact, spraying as against the second brood is not usually done at all in New Jersey.

The trap-bands of burlap tied around the trunks of the trees were examined from time to time, and whenever a larva or pupa was seen it was killed. At the end of the season the bands were taken off and burned, while any larvæ adhering to the bark were killed. This banding is an old-fashioned method, yet it is almost entirely relied upon in Europe, and it forms an excellent supplement to our spraying practice.

Other Fruit Insects.

There are always small outbreaks, due to local conditions, which are brought to the notice of the Entomologist, and of such character was the occurrence of pear psylla, in Mercer county; of currant slugs, in Middlesex county; of the rose-bug, in Bergen and Burlington counties; of the grape procris, in Salem county; of the grape fruit-worm, in Middlesex county; of the apple-borers, in Somerset county, and of the fruit bark-beetle, in Gloucester county.

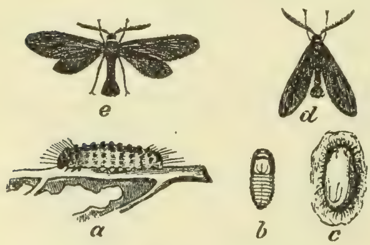

Fig. 17.
The grape Procris: *a*, larva; *b*, pupa; *c*, its cocoon; *d*, adult moth at rest; *e*, same with wings expanded.

Sometimes even a beneficial insect develops hurtful tendencies, as when, in Cape May county, wheel-bugs, whose favorite diet is caterpillars, were caught preying upon honey bees.

Caterpillars.

Caterpillars of all sorts have been rather conspicuous by their absence, and this applies as well to those injurious to shade trees in cities as to those affecting field and orchard crops.

Tent caterpillars appeared early, but disappeared almost before their presence had been realized; yet they left relics of their presence, and I found in the fall an unusual number of egg masses. Unless signs fail, there will be more of them next year (1904) than were present in 1903.

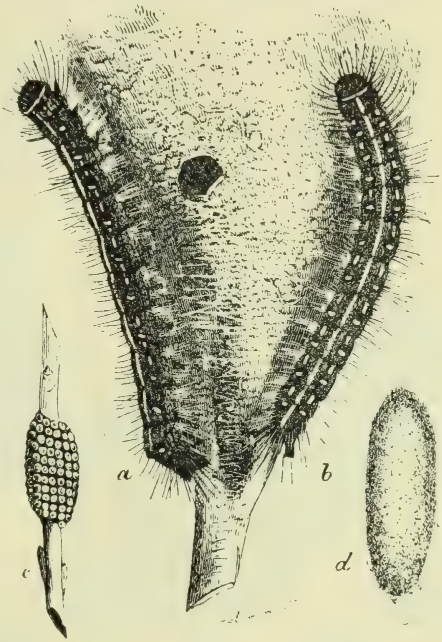

Fig. 18.
Tent caterpillars, full grown, at base of their nest, near its opening.

Web-worms were almost altogether absent. I noted some in the fence rows on wild cherry, and, in the northern parts of the State, quite a few on walnut and butternut, but in orchards almost nothing. On my own trees not a single web developed during the season, and one lot of yellow-necked caterpillars was all that I had to deal with in this line.

Shade Tree Pests.

The plant lice infesting this kind of trees have been already referred to, and caterpillars have bothered them little.

The *Leaf-stalk Borer* on maple seems to be spreading, and was reported several times very early in the season, but thus far it has not gotten out of Essex county. The parent of the little, boring larva has not yet been identified.

Cynipid Galls, caused by minute wasps, have been abnormally plentiful on oaks, and leaves almost covered with spherical galls as large as a good-sized pea or larger were received from many parts of the State. Though they are somewhat disfiguring, these galls cause

no permanent injury to the tree, and they are not likely to recur next season in the same abundance.

Other pests sent in as injuring oaks were mostly secondary in character—*i. e.,* they were such as came in after the tree had been injured in some other way. There is no doubt that many forest trees in streets and lawns are dying as the result of the abnormal conditions under which they are placed. The attempt to get a lawn under the trees, or to cover the surface with any material through which water and plant-food does not penetrate readily, creates a condition that reduces their resisting power, and makes them ready victims to bark and other borers.

Fig. 19.

The elm-leaf beetle: *a*, *a*, egg patches on leaves; *b*, larva, feeding; *c*, adult—all natural size; *e*, egg mass; *f*, surface of egg; *g*, larva; *h*, *i*, details of larva; *j*, pupa; *k*, adult beetle; *l*, its elyra—all enlarged. From Riley, U. S. Dept. Agl.

Elm-leaf Beetles are again becoming more plentiful, and at New Brunswick defoliated some of the unsprayed trees rather thoroughly. The disease noticed in Newark, and to which reference was made in a previous report, seems to have been general in Essex county and vicinity, for less trouble appears to have been noted there than elsewhere in the destructive range of this insect.

Nut Weevils.

The growth and harvesting of hickory-nuts, walnuts and chestnuts is on the increase in New Jersey, and in some years decidedly profitable. Every year an excellent nut exhibit is shown at our fairs, and systematic attempts are made to improve the native varieties of hickory-nuts. Chestnuts are quite extensively grown, and of these it has been long known that they are infested by "worms" or "grubs." More recently a little caterpillar has begun to feed in the burs before full growth has been attained, and this seems to check development and causes a premature dropping. I have not yet bred the insect, hence cannot speak definitely as to its identity and habits.

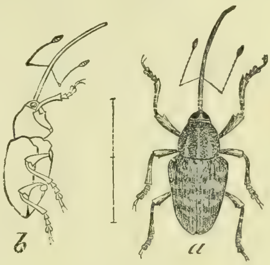

Fig. 20.

Nut weevils from above and side.

Many hickory-nuts are grown in Burlington county, and one correspondent speaks of a "shellbark tree which, a few years ago, bore nuts of large size, fine flavor and all sound. For some years back the nuts have been wormy and entirely worthless. They grow fully as large as formerly." And this is not unlike other communications on the same subject.

The parents of these "worms," in both hickory-nuts and chestnuts, are stout, yellowish weevils, which have a long, slender, somewhat curved, black beak or bill. By means of this they bore through the burr or hull soon after it has set, and in each hole so made the beetle lays an egg. When the little grub hatches it is right in the forming nut, while the narrow channel through which it was introduced is closed completely by the growth of the hull. In the native chestnuts there is rarely more than a single worm to a nut. In the large Spanish or Japanese varieties there may be half a dozen. When the nuts drop the "worms" are full grown, eat a round hole through the shell, crawl out and bury themselves in the ground. Under natural conditions they meet many enemies here, and only a small percentage comes to maturity. Under the artificial conditions of clean, open surroundings these natural enemies find themselves not at home, and the weevils, therefore, pass through their changes safely in ever-increasing numbers.

It is obvious from the life cycle just given that insecticides are useless as against this insect in all stages. There is only one thing to be done, and that is to gather in all nuts just as soon as they drop from the tree and put them in barrels, tubs or other deep receptacles with tight bottoms. The worms will emerge from the nuts, but will be unable to escape from the barrel, and may be killed by pouring an ounce or two of bisulphide of carbon through a tube forced into the nuts to the bottom, or they may be left until the nuts are used. They must never be dumped upon the ground, unless they are to be killed at once. Even a single year of this practice will make a difference; but it is a provision of nature for the benefit of the insect that they do not all mature the same year. Of one hundred worms that bury themselves this fall, perhaps seventy will come out as beetles next spring (1904); twenty more will lie over to emerge the year following (1905), and the remainder will not make their appearance until the third year thereafter (1906). By keeping up the collecting, however, the burial of new worms will be prevented, until only a small percentage of wormy nuts appear in the crop. The method is a little troublesome, perhaps, but quite practical and entirely effective.

Potato and Tomato Pests.

The *Potato Beetle* has been with us, of course, but not in such abundance as usual. and there seemed to be less difficulty in keeping it in check.

Flea Beetles were more troublesome, and were reported on tomatoes and eggplants, as well as on potatoes. In fact, where the latter crop is systematically sprayed with either the arsenites or the Bordeaux mixture the insects do not make much headway.

A more troublesome pest was a *stalk-borer,* which appeared locally in Mercer county and "played havoc" in some tomato fields. This is the caterpillar of one of our night-flying moths, a species of *Hydroecia* which bores also into the stems of nettles, ragweeds and a variety of other plants. The species is not unknown as an injurious one, yet it does not often appear in troublesome numbers in New Jersey; in fact, it is uncommon rather than otherwise. We are rather helpless against such borers when they occur so irregularly, and can only suggest the removal and destruction of an infested plant as soon as it is noticed.

While this does not lessen the present damage, it may lessen the injury for next year. An incidental suggestion is that ragweed, horse-nettle and similar weedy plants be kept down as much as possible.

Cabbage Insects.

The cabbage crop has, on the whole, escaped much better than usual. There were few complaints of the usual cabbage-worms, and the loopers were hardly to be found at all, where ordinarily they are troublesome late in the season. The parent butterflies were quite noticeably less than usual, and this point was already obvious very early in the summer. It is probable that the peculiar combination of climatic conditions is responsible for this.

Cut-worms were reported, but more on cauliflower than on cabbage. The poisoned-bran method of dealing with these pests is so well known, however, to growers in general that, as a rule, it is resorted to at once, and I hear only of unusual cases or from someone who has not previously identified the character of the injury.

Household Insects.

It is not only outdoors and on crops that insects are troublesome; some of them live with us in our houses, and even upon us, if we are not careful. To a greater extent than ever before have questions come in concerning these insects, not, perhaps, because they were more abundant than usual, but because the desire to be rid of them was more intense.

The *Carpet Beetle* was the most usual subject of inquiry, though, as already stated, the two-spotted lady-bird was several times mistaken for this pest. The beetle itself is rather a pretty creature when seen under a lens, with its mottled mixture of red, brown and white scales arranged as shown in the figure. It lives only on pollen and flower juices and is not injurious. But its larva, the so-called "buffalo moth," is different. It eats dried animal matter of all kinds, and has an especial fondness for woolen goods. Carpets are most frequently attacked, because they are most accessible, and the insect works chiefly around the edges or where a heavy piece of furniture makes a depression.

Where these insects are noted at work and the carpets cannot be conveniently taken up to be cleaned, gasoline should be liberally used. It will harm nothing except the cheapest fabrics, and is sure death to all insects that it touches.

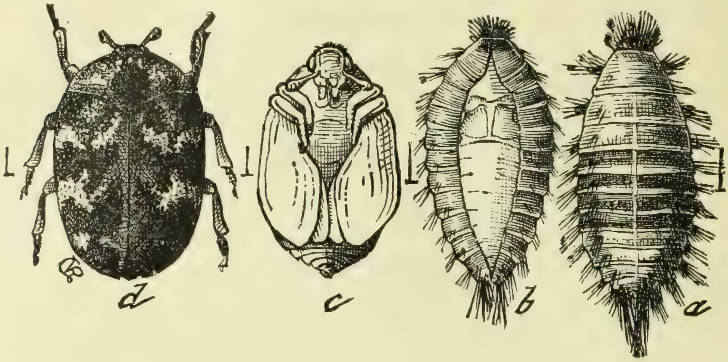

Fig. 21.
The carpet beetle : *a*, its larva or Buffalo moth ; *b*, pupa resting in larval skin ; *c*, pupa ; *d*, the adult—all very much enlarged. From Riley, U. S. Dept. Agl.

The *Larder Beetle* is an allied species, but much larger, and is no stranger in farmhouses. The beetle itself is about one-quarter of an inch in length and usually manages to escape unseen, though its contrasting black and gray wing covers would seem to make it rather conspicuous. Its larva is a rusty brown, hairy grub, with rather a tough skin, and is easily found when it occurs in any numbers. A typical letter refers to specimens—"found in a closet where I keep hams hanging and which is also a general storeroom. They had burrowed into one ham and were all through contents of closet. I fumigated with sulphur, had closet well scrubbed and the cracks painted with pure carbolic acid and still find them about."

The sulphur treatment is a good one, and, where a confined space is to be treated, should be used in great excess, but always place the candle in a plate or pan of water, as this will form a combination of fumes and moisture that is much more penetrating and deadly than the dry fumigation would be. Gasoline should replace the carbolic acid under the circumstances cited. Sulphur must not be used where brass or nickel fittings occur.

The active little creatures known as *"silver fish"* because of their glistening, white, scaly covering, are often seen in kitchens, dry closets or drawers, and their presence always causes a certain amount of uneasiness to the careful housekeeper. As a matter of fact, they cause no real harm, gnawing bits of starchy material from dry bread, glazed paper or laundered clothing, yet they are not pleasant to have around, and may be kept out by naphthaline, lavender or almost any other real pungent odor. In kitchens they should be killed whenever seen, and, as their rate of reproduction is not very great, this will gradually reduce their numbers to the vanishing point.

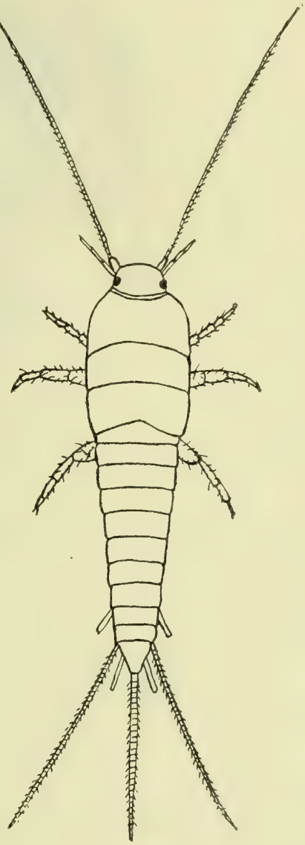

Fig. 22.
A silver fish.

Fleas are not at all uncommon in houses, and almost every season there is a real epidemic somewhere. The original source of infestation is nearly always a pet dog or cat whose bedding has been neglected. Fleas lay their eggs, not on the animals infested, but in the bedding, whatever it is, where they sleep. The larvæ are minute, slender, white, worm-like creatures that live on almost any kind of dead material. The moist dirt in the crevices between floor boards, moist saw-dust, dirty rags of animal bedding and the like are all equally acceptable, and in a few weeks they may increase so as to spread all over a house.

The first thing to be done is to clean out the animal's bedding and its surroundings, using whitewash wherever possible to freshen up and disinfect damp cellar or basement areas. Floors should be scrubbed, and, when dry, gasoline should be poured along the cracks between the boards to kill any larvæ yet undeveloped. Thoroughly wash the dog or cat with some carbolic or other good dog soap and let it have the run of the infested rooms for a day or two. Then repeat the washing, and continue this procedure until all the adult fleas have been caught off and killed. The fleas have no way of get-

ting food except from animals, and cannot maintain themselves except on hairy animals; therefore, they will get upon a dog or cat as soon as they have an opportunity to do so. In other words, the whole method consists of using the animal as a trap.

Fig. 23.
A flea.

Occasionally a storeroom or garret containing furniture, hangings, bedding and the like becomes infested by moths or other objectionable creatures, and the question arises how these may best be dealt with. A correspondent writes as follows: "I have a large room, about 40 x 75 feet filled with antique furniture, the walls are covered with tapestry and the floors with very large, heavy rugs; there is also much polished brass. The room has become full of moths, and I wish you would inform me if it would be possible to use hydrocyanic acid gas without destroying finely-tinted silks, etc."

As this was an extreme condition I consulted with Professor W. G. Johnson, who has had more experience with the hydrocyanic gas than any one other person, and he assured me that in cases of that character the gas could be used with safety to the contents and absolute effect against the insects. The method is equally available where, instead of moths, such creatures as bed-bugs are to be dealt with.

A rather unusual case was an attack of Termites, which came through a floor and destroyed a fibre carpet that covered it. It is so rarely that a case of this character is met with that each must be dealt with according to its own peculiarities.

Miscellaneous.

No bulletins have been issued from this department since the date of the previous report, but material is in hand for publications dealing with insecticides, with some of the more common mosquitoes of the State and with certain shade-tree insects.

The work of the State Entomologist has increased under an increased appropriation, and Mr. E. L. Dickerson has been appointed as permanent assistant. Rules have been formulated to facilitate the inspection work, and the register and examination of nurseries within the State is now more complete than ever before. Early in June I attended a meeting of the National Association of Nurserymen, at Detroit, Michigan, where the question as to the relation of nurserymen to the Inspection law was discussed. A full report on this work is made to the State Board of Agriculture.

The mosquito investigation was planned to extend through a period of two years, hence only a report of progress is presented at this time. So far the work has been satisfactory, and it is believed that when the results are finally presented the effect will be seen in the gradual carrying out of the suggestions to be made.

The reference made to collections in my last report indicated the necessity for a safer housing, and this necessity has been quite forcibly illustrated by the fire already referred to. Owing to the excellent rescue work done by the College students, practically all the collection was saved; but there is considerable damage and a great disarrangement, which has made it unavailable for purposes of study. The Station needs a fireproof annex in which the valuable records and collections can be safely placed.

At the request of the Director of the Office of Experiment Stations of the United States Department of Agriculture, Farmers' Bulletin No. 178, dealing with Insects Injurious to Cranberries, was prepared by the writer. This publication is available to our growers, and is of really greater importance in New Jersey than in any other State, except Massachusetts.

There has been no decrease in the number of lectures and addresses before agricultural bodies, and I have continued my connection with the societies and associations, local and national, at which subjects of importance to my department are discussed.

The correspondence of the department during the calendar year 1903 covers 3,000 pages of letter-book, representing upward of 1,500 individual communications.

ENTOMOLOGY IN THE CROP BULLETIN.

The first species mentioned, May 5th, in No. 1 of the Crop Bulletin, was the asparagus beetle, which was then numerous at South Bound Brook, Somerset county. It was again found to be abundant at Mickleton, Gloucester county, August 25th, and that was all.

Tent caterpillars were reported as numerous or abundant as early as May 12th, at Rocksburgh, Warren county; Frenchtown, Hunterdon county, and Hightstown, Mercer county. On the 19th of May they were yet numerous at Frenchtown, and had become troublesome at Grover, Hunterdon county. They continued noticeably a week later, and then all mention of the species ceases.

Potato beetles or their slugs began to attract attention May 26th, at Cranford, Union county, and Frenchtown, Hunterdon county. On June 2d they were reported from Grover, Hunterdon county; Piscatawaytown, Middlesex county, and Warrenville, Somerset county. June 30th they are recorded from Layton, Sussex county, and not again during the season.

From Moorestown, Burlington county, the report came August 4th, that orchard fruits were nearly exempt from caterpillars of all sorts this year.

Currant-worms were destructive at Livingston, Essex county, June 2d, and that was all.

Squash bugs attracted attention once only, at Warrenville, Somerset county, June 16th.

Plant lice were more frequently seen. On grape they appeared at Paterson, Passaic county, June 30th, on which date, also, "all fruit trees were lousy" at South Bound Brook, Somerset county. Apple lice were reported from Elizabeth, Union county, July 14th only.

Leaf-hoppers on grape attracted attention at Bayonne, Hudson county, August 11th.

Cabbage-worms appeared, without doing serious damage at Bergen Point, Hudson county, August 25th, and on the same date katydids and locusts were numerous at Frenchtown, Hunterdon county.

On the whole, this is the most remarkable record that is within my recollection; not for what it contains, but for what it does not contain. Scarcely any of the normally injurious forms appeared in notable numbers, and there is not a single reference to cut-worm, plum curculio or codling-moth. Of course, this absence of record

does not necessarily indicate the absence of the insects, and it may be that the climatic conditions so dominated everything else that the minor difficulties passed unnoticed.

INTRODUCED BENEFICIAL INSECTS.

The Chinese Mantids.

There is no doubt that these insects have become established at various points in New Jersey, but they are nowhere numerous enough yet to attract much attention. Egg masses from the introductions made last year were found at New Brunswick, and in Burlington, Gloucester and Atlantic counties. Adults were also observed from last year's introduction during the past summer in numbers sufficient to warrant the belief that the species will maintain itself.

To increase the chances of success, however, I secured another large lot of the egg masses through Mr. Philip Laurent, and, during the latter part of February, distributed them in lots of about thirty masses each, as follows:

Mr. Charles B. Horner, Mount Holly, Burlington county, who did not acknowledge receipt; but told me later in the season that they had been received, placed according to directions and that specimens had been seen in the late summer.

Mr. H. W. Collingwood, Woodcliff, Bergen county, received the specimens, set them away and forgot all about them until May 1st. Then, on opening the package, "I will guarantee that there were 15,000 insects hatched out and crawling about as lively as crickets. This was a pleasant surprise to us, and I am populating the entire farm with them, and also giving a few to all visitors, so that they can carry on their good work all over the district. That was certainly the most surprising hatch we have ever had at Hope Farm, and we will take good care of the young things, and do the best we can to bring them up properly. I suppose they will thrive almost anywhere now; at least, I am going to turn them out here and give them a chance for their life." May 1st is rather early for the species to hatch outdoors, and it is quite probable that a large perecentage of the specimens died off during the cold weather of that month.

Mr. T. E. Steele, Palmyra, Burlington county, put the masses on a great variety of trees and plants in his garden and nursery. They began hatching late in May, and "on the 31st I had the pleasure of

seeing three lots of them come out, and I watched them with much interest. They came out and formed on the side of the mass like a swarm of bees, and one by one they crawled up over each other and found the very top of the tree, and about one hour later they all disappeared." In early September Mr. Steele told me that several specimens had been seen in neighboring gardens, where, no doubt, egg masses will be found during the winter.

Mr. Fred. A. Schmidt, Woodbine, Cape May county, placed some of the masses on shrubbery on his own place and some on various trees and shrubs on the school farm.

Messrs. Stoye and Steele, Eatontown, Monmouth county, placed the masses in different parts of their nursery grounds in a variety of shrubs and trees. They seem not to have been noticed later, but no especial search was made for them.

Mr. Henry Pfeiffer, Cologne, Atlantic county, distributed twenty masses in blackberry patches, twelve went into a vineyard and the balance into apple trees. All the specimens hatched, and a number were noticed when blackberries were picked. "They are more active than our wheel bug, and will hide from view."

Mr. John Repp, Glassboro, Gloucester county, placed the masses in his orchard trees, and noted at that time egg masses deposited by the adults from the egg sent the year before.

Mr. Arthur J. Collins, Moorestown, Burlington county, tied all the masses on apple trees in his orchard; but made no report of having seen them later.

Thirty-five egg masses were distributed along the road between South Orange and Hemlock Falls by Mr. E. L. Dickerson. There is a good tangle of shrubbery at several points, and these are much like the places where Mr. Laurent found the egg masses most abundantly near Germantown.

Another lot of over thirty masses was placed on the College Farm, along a wooded border with much undergrowth.

I did not keep any for my own garden; but several specimens of the adults were seen by various persons during the late summer—evidently the descendants of the specimens seen here last year. One female was rescued from a kitten, October 28th, and brought to me, none the worse for its experience.

Altogether about 350 egg masses were distributed by me, representing at least 30,000 specimens. There seems to be no reason why, at some of the points selected, the insect should not establish itself.

Mr. Laurent distributed about 100 egg masses on Five-mile Beach, chiefly near Anglesea, and if the insect will thrive at all near the seashore, this would seem to be an ideal place for it.

As the insect was treated at some length in the Report for 1902, nothing need be here added to the mere record of the distribution.

The Chinese Lady-Bird Beetle.

Chilocorus similis.

In the Report for 1902 I gave a brief statement of the connection between this insect and the San José or pernicious scale—the Chinese scale, as Mr. Marlatt suggests it should now be called. I also pointed

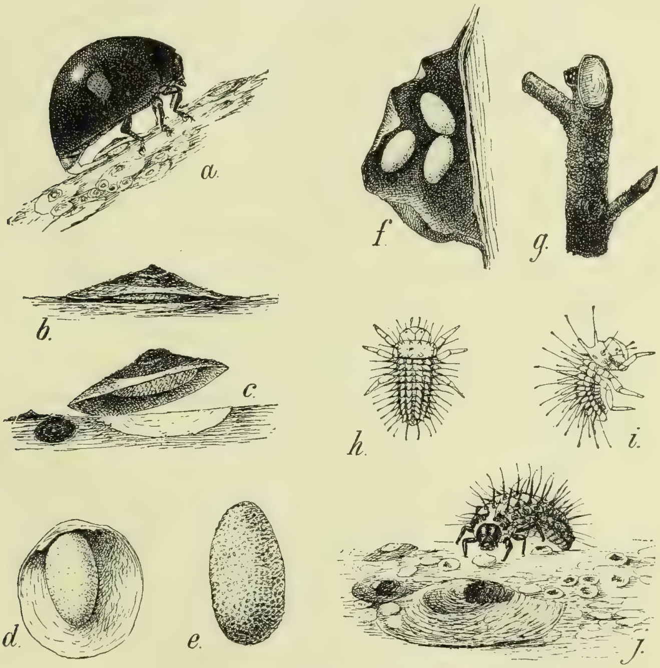

Fig. 24.

Chilocorus similis: a, beetle thrusting egg under a scale; *b*, scale raised showing edge of egg beneath it; *c*, scale lifted to show egg under it; *d*, scale from beneath, showing egg; *e*, egg. much enlarged; *f*, three eggs under a flap of bark; *g*, same, natural size; *h*, *i*, newly-hatched larvæ; *j*, same, feeding on scales. From Marlatt U. S. Dept. Agl.

out what attempts had been made to introduce it into this country, and recorded the history of the specimens, larvæ and adults, that were received by me.

The condition of the two colonies in my charge last fall was such that I decided to keep them undisturbed under the cages during the winter. The tall grass and weeds, with the fallen leaves, formed an excellent shelter around the base of the trees, and on tree 36 the effects of scale and woolly louse left the bark in such condition that there was plenty of chance for hiding-places, should such as these be preferred.

At various periods during the winter and early spring some beetles were seen, but very few of them survived, and no larvæ were actually seen on either tree until June.

At no time during the season were any large numbers of larvæ present, and before the end of the summer it became quite evident that a parasite was at work that materially retarded the multiplication of the species. In early September it became clear that the covered trees would not survive another winter, and, as beetles were maturing rapidly, I concluded to distribute the entire stock in hand to points south of New Brunswick, to give them a somewhat better chance for life.

Boxes, each containing twenty or more pupæ and adults, were shipped by mail to—

Horace Roberts, Fellowship, Burlington county.

Arthur J. Collins, Moorestown, Burlington county.

Henry I. Budd, Mount Holly, Burlington county.

Granville W. Leeds, Rancocas, Burlington county.

Nelson P. Creeley, Burlington, Burlington county.

J. Lawrence Lippincott, Riverton, Burlington county.

John R. Parry, Parry, Burlington county.

E. T. Gill, Haddonfield, Camden county.

Daniel W. Horner, Merchantville, Camden county.

Henry Pfeiffer, Cologne, Atlantic county.

Peter J. Delzeit, Rosedale, Atlantic county.

John Repp, Glassboro, Gloucester county.

B. F. Maul, Greenwich, Cumberland county.

Fred. Schmidt, Woodbine, Cape May county.

S. B. Ketcham, Trenton, Mercer county.

The specimens sent to Mr. Schmidt were turned over to Mr. Charles Howell, of Dias Creek, because there is no pernicious scale in Woodbine.

Mr. John R. Parry received two sendings, one of which was liberated on the farm occupied by Mr. John Banff, and the other on the farm

occupied by Mr. John Strable. Earlier in the season Mr. Parry had received a colony of eight living beetles from Dr. L. O. Howard, which he liberated on his own place.

Mr. William S. Parry, Cinnaminson, Burlington county, received a colony of twelve living beetles from Dr. Howard about August 30th, and liberated them under favorable conditions.

All of the parties to whom the sendings were made acknowledged receipt, and in all save one instance the specimens arrived in good condition. The total number of sendings made is sixteen, and, assuming an average of twenty specimens to each sending, fully 360 examples were liberated under more favorable conditions than those under which their parents passed the winter of 1902–'03. Counting the specimens received from Dr. Howard, the number will reach at least 400, since some of my sendings ran well over twenty examples.

Although the species has wintered one season in New Jersey, and the present supply is nearly all New Jersey born, yet we cannot be sure that the liberated specimens will do well under natural outdoor conditions.

In Georgia, conditions seem to be much more favorable, for the colony there, introduced at the same time that I received specimens in New Jersey, has now multiplied enormously. Mr. Marlatt writes on this point as follows:

"The rather successful Georgia colony, to which I referred in my letter to you of the 3d of July, was visited by Mr. Kotinsky and Mr. Scott a little later, and found to be in a most flourishing condition. They estimated that in this orchard of some 17,000 trees there was upwards of 30,000 or 40,000 beetles. these creatures having spread all over the orchard. Adjacent to this orchard is a much larger one, belonging to the same person, of 250,000 trees, also infested by the scale, into which the beetle will soon migrate or be carried. Furthermore, a good many colonies have been sent out locally from this one, and in one or two instances it seem to have gone to adjacent orchards of itself."

If, as is to be expected, these insects hibernate well in Georgia, it will be my effort to secure a goodly supply early in the season of 1904, that they may have a chance to spread in some of our own orchards during the summer.

Judging by the difference in breeding records, it would almost seem as if New Brunswick was really beyond the northern limit at which this beetle can be expected to do good work; yet Mr. Marlatt

shows that in Asia its range north is much greater, and that our climatic conditions can scarcely be said to be beyond the experience of the species.

A more obvious danger lies in the presence of the parasite to which reference has already been made. There is no doubt that the possible supply in my cages was lessened by fully 33 per cent., and Mr. Marlatt fixes his own loss at Washington, from the same cause, even higher. In Georgia no trace of the parasite was observed.

The species in fault is a minute, bronzed or blackish wasp, full twenty of which may develop within the body of a single full-grown larva or pupa. Its life cycle is only about two weeks from egg to adult, and, as the beetle is, in comparison, a slow breeder, the parasite has a distinct advantage.

This harmful little creature is known as *Syntomosphyrum esurus* Riley, and was found by that writer preying upon the cotton-worm. It seems to have been obtained also from other hosts, so unlike in general character as to suggest that it is a secondary feeder upon some other genus of parasites. But Mr. Marlatt's observations seem to negative this, and to prove that it is a real and primary form, which may seriously interfere with the experiment in hand.

Mr. Marlatt gives some account of his journeys in Asia in the Year-book of the United States Department of Agriculture for 1902, and from that, from information obtained directly from him and from the observations made at New Brunswick, the following account of the development of the *Chilocorus similis* is made up.

It winters in the adult or beetle stage, and, in the confinement of a cage, at least, this is a period of danger for it. None of my original sending in 1896 survived, and of Mr. Marlatt's imported specimens only two passed through safely. Only one of these was a female, and from that one example all our present stock is derived. Exactly how many of my examples came through safely I cannot say, but there were several in each cage, indicating a fair degree of hardiness.

At Washington, egg-laying began in April and continued throughout May, larvæ hatching in about a week or ten days. At New Brunswick no larvæ were observed until June 22d, but at that time some of them had already pupated, and therefore the end of May can be assumed as the probable date for the first oviposition.

The method of egg-laying is peculiar, and is described by Mr. Marlatt as follows: "The egg is normally concealed under an adult female scale. The parent beetle selects a suitable scale, drags out the scale

insect underneath it, turns about and thrusts the ovipositor under the slightly-lifted edge of the scale, and in two or more minutes deposits a single egg in the cavity, very often slowly masticating meanwhile the scale insect which has been made to yield its place for the egg. This habit of oviposition seems peculiar to this species, and does not correspond to the closely allied native species. It was found later on, however, when beetles became numerous, and especially during the period when old female scales were not abundant, the

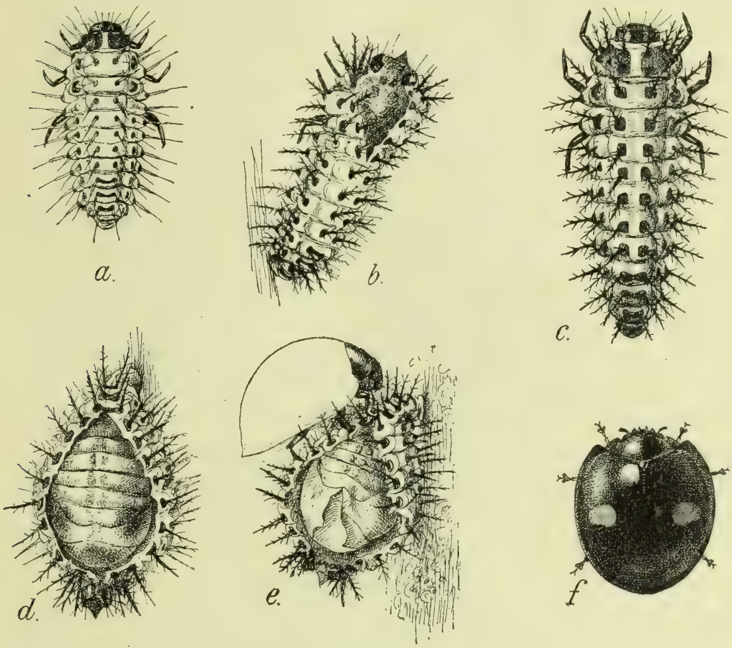

Fig. 25.

Chilocorus similis: *a*, second larval stage; *b*, its cast skin; *c*, full-grown larva; *d*, pupa as it appears in split larval skin; *e*, adult just emerged; *f*, fully-colored adult. All enlarged to the same scale. From Marlatt, U. S. Dept. Agl.

trees being covered with young scale insects, that other locations would be chosen by the beetle for oviposition, such as beneath a loose edge of bark, or more rarely, eggs would be deposited exposed on the bark."

The larva that hatches from this egg is a minute, spiny creature, of a rather dull flesh color, and it feeds, by preference, on the newly-hatched or very young scales. The early specimens, hatched in April or May, must depend upon the older scales entirely, since with us

no scale young appear until June. It is really this brood of larvæ which should be of the greatest benefit, because nearly every scale insect eaten during May is a female, and means an enormous decrease in the breeding possibilities. It is also in this point that the New Jersey specimens have failed thus far, because they did not get to work early enough to reduce the first scale mothers.

The life in this stage seems to be about two weeks or a little over, and then the larva, now of a reddish pink tinge, with black branched spines, fastens itself by the tail, hunches itself up into a little ball and changes to a pupa. This pupa lies inside the larval skin, which splits along the back and forms a sort of cradle or basket, in which it rests. The duration of this stage varies, but may be two weeks or more late in the season, so that the period from egg to imago may be from thirty-five to forty-one days, or even longer. I am inclined to believe that it is more nearly fifty days in New Jersey, and that we have, in New Brunswick at least, not over two broods. After June 22d larvæ, pupæ and adults could be found on the trees at all times. At Washington and to the south they have at least four broods, and possibly more. The adult beetles, when they first crawl out of the pupal skin, are almost yellow in color, but darken rapidly, and soon become black, with an orange spot on each wing cover.

As compared with *C. bivulnerus,* our native species, *C. similis* is almost indistinguishable in the adult stage; it is a little smaller, the spot on the wing cover is a little different in outline and the color is a little different. All these points are obvious when a large series of both species is at hand, but they become useless when only one or two examples are at hand for determination.

But in the larval stage it is different. The native form is blackish, with a whitish, transverse band, and the branched spines are very much longer and more prominent; as a whole, very unlike the flesh-colored grub of the imported species. As to the rate of multiplication, Mr. Marlatt considers this most satisfactory: "It has at least four broods in a summer, and a single female will produce 500 young." He says further, as to its appetite, that "its larva destroys an enormous number of young scale larvæ in a day. While actively feeding it eats five or six scales a minute, and even if it averaged but one a minute, this would be a total of 1,440 scale insects destroyed per day. Its appetite seems never to be satisfied, and it is eating practically all the time. The adult also feeds actively on the scale insects."

Summarized, the present condition of the experiment is as follows:

Chilocorus similis is a "lady-bird" bettle, which, in Asia, is an effective agent in keeping down the pernicious or San José scale.

The species has been introduced into New Jersey, and has passed through one winter in confinement. It breeds rapidly and is a constant feeder, hence an excellent check to the scale.

In the latitude of Washington, D. C., the beetle begins to oviposit in April, and feeding by the adults and larva continues for more than a month before the scale larvæ appear. At New Brunswick larvæ of the beetles are not present until the first days of June, or just about the time when the scale larvæ also appear.

The life cycle of the bettle from egg to adult ranges from thirty-five to forty-five days, or a little longer in late summer. A female may deposit 500 eggs, and usually takes nearly a month to do it. After the 20th of June, at New Brunswick, larvæ, pupæ and adults occur together throughout the remainder of the season.

The beetle is subject to parasitic attack, and is also preyed upon by ground beetles and a number of other predatory forms. It becomes a question whether its rate of increase is sufficient to produce a number great enough to be of any material benefit.

The experiment should be continued until it is proven, either that the insect will not thrive in New Jersey, or until it is thoroughly established.

INSECTICIDES.

Details concerning the applications of some of the mixtures tried are found in the records of the Experiment Orchard. There was no effort made to try any very large number or variety of materials; rather, to test the usefulness of a few compounds that offered a prospect of becoming useful as against scales and other sucking insects. I did not mean to, nor did I, rely upon my own experiments only. I followed out the work done by some of our best horticulturists, and personally, or through one of my assistants, verified the results.

There is an increasing tendency among our farmers to try experiments, and some of their combinations are likely to prove useful and to merit further trials; so I attempt, as far as I can, to learn of what they have done and what the results have been.

Kerosene

This is still used undiluted by a number of growers for a summer application, with very good results. Sprayed through a fine Vermorel nozzle on a sunny day, so as to cover, and no more, it forms one of the most effective insecticides against plant lice, scale larvæ and recent scale sets. Only peach is at all sensitive to the spray, and even this can be safely treated if care is used. As a winter treatment it has lost favor.

The mechanical mixture of kerosene and water, ranging all the way from 15 to 25 per cent., is quite commonly used for summer work, and the stronger of the two mixtures is used for winter work against the pernicious scale with very unsatisfactory results on the whole. In New Jersey, nothing less than 33 per cent. is sufficiently effective to warrant its use as a winter application. One rather interesting experiment reported to me consisted in painting a number of pear fruits with clear kerosene to keep off scales. When I saw them a month or more afterward the fruits were certainly clean, but whether this was due to the kerosene I cannot say.

Kerosene emulsions with milk or soap are not much in use now. The labor attendant upon making them deters many, and it is certain that, combined with soap, the kerosene is more injurious to plant life than in a mechanical mixture. This is especially true if a large percentage of oil is desired for winter work.

Crude Oil.

Experience is gradually fitting this material into its proper place. Those who have used it most extensively are yet using it, but in a more limited way. It may be remembered that the first experiments made with the material was on pear, and some of the most satisfactory results obtained have been on this kind of tree. I have, from time to time, published especially good results, and in other States as well, pear seems somehow to have responded best to oil treatments. Systematic observations and experiments made by a Mercer county horticulturist who has also used the lime, salt and sulphur wash for two years, leads him to say that while the sulphur wash is undoubtedly best for apple, peach and plum, the oil is much better for pear. Not only does it kill the scale more effectively, but it exercises a

specific effect upon the tree, forcing a rich, healthy growth and clearing up the fruit as nothing else can. The latest experiment was with an orchard of Lawrence trees, which for several years past had produced a scant set of poor fruit; so poor that it had to be sold last year (1902) at 20 cents per basket to get rid of it at all. Though it was not much infested by scale, it was determined to try the effect of the oil, and the trees were so heavily sprayed that they were ten days late in starting. After they did start, however, their growth and condition left nothing to be desired, and they made a heavy crop of nice, clean fruit, not a basket of which sold for less than a dollar.

For young pear trees the oil is not recommended, but for old, rough-barked trees, that tend to become hidebound and stop growth, the oil seems to act as a stimulant, while also cleaning upon the conditions that tend to the clouding and spotting of the fruit.

A point to be noted is that those who have used the oil to best advantage claim that it should be slightly warm. It sprays much easier, is more penetrating, spreads more thoroughly and is much less apt to cause injury. It can be applied in a finer spray, and it goes further.

Summer applications of crude oil are rarely made now, but on apple and plum winter applications continue, though the tendency is to use a 20 to 25 per cent. mechanical emulsion. Thoroughly applied, the latter seems to be quite satisfactory.

A Gloucester county apple grower uses five gallons of crude oil to every 200 gallons of Bordeaux mixture in the first spraying, and believes that it adds to the effectiveness of the copper mixture, while reaching also the apple lice which at that period make their appearance on the trees. The oil is added in the proportion given to the Bordeaux mixture and is stirred in well. It seems to remain fairly well in combination and causes no trouble in the spraying; indeed, it seems to improve it rather than otherwise.

I heard, also, of one man who added a pint of lubricating oil to every barrel of the lime, salt and sulphur wash, and claimed that it reduced the wear upon the pump by keeping it oiled internally.

There has been, also, the usual crop of trees injured by the oil, and an incident to show how much this depends upon the individual is related by a South Jersey horticulturist. He sprayed his orchard with oil in ordinary course, and was asked by one of his neighbors to lend his pump when through. He did so, and gave him, also, sufficient oil to spray the few trees that were to be treated. Not one of the

trees out of thousands sprayed by the first man showed any trace of injury, while of the few sprayed by the neighbor almost every one was killed or seriously injured. The varieties were like some of those uninjured, and, except for the man that made the application, conditions were apparently alike. It is to be always understood that, when I refer to crude oil or crude petroleum, a material is intended which will register 43° or over on a Beaumé oil hydrometer.

Lime, Salt and Sulphur Wash.

The formula recommended by me is:

Lime unslaked	50 pounds.
Sulphur:—flowers or ground	50 pounds.
Salt	50 pounds.
Water	150 gallons.

This formula is easily recommended, since it calls for equal parts of each of the substances, while the water is equal to the sum of all three in gallons. Or it may be put that there must be three times as many gallons of water as there are pounds of sulphur.

Slake the lime and add the sulphur while this is doing; then boil for an hour, adding water from time to time as may be needed; then dissolve the salt and add to the boiling mixture slowly, and when all has been thoroughly combined, add the necessary amount of water, preferably at least warmed. Spray while hot—not because the spray will be hot when it reaches the tree, but because it works more easily and is in a more perfect chemical combination than at any time afterward. All those who have made the wash agree that if it is allowed to get cold and to stand for twenty-four hours it forms a sediment, which cannot be recombined and which cannot be satisfactorily sprayed.

Experiment seems to have proved that the salt is not an essential part of the wash. The active agent is the combination formed by the lime and the sulphur; the salt adding somewhat to the stability of the mixture and to its sticking qualities. Even the last point has been disputed, while, on the other hand, the only New Jersey grower who omitted the salt altogether concluded that he had made a mistake, and will return to the original formula. The amount of lime in the formula should not be reduced, but is sufficient. Some add

one-half more and others twice as much as there is sulphur. But whatever lime remains after the sulphur is fully taken up makes whitewash merely, and in my opinion is harmful, rather than otherwise, because it forms a thicker coating, which is more apt to flake off. Yet, if only a small amount of the material is to be made up, an excess of lime is beneficial, rather than otherwise, since it facilitates the combination.

It is quite the practice, where large quantities of the wash are to be made, to use a steam cooker or boiler, and the most thorough combination has been produced by the following method: In one barrel slake nine pounds of lime with warm water, using just enough to prevent burning, and, while slaking, add seventeen pounds of sulphur, using in all about five or six gallons of water; then turn in the steam-pipe and cook, with not over seven gallons of water, for about one and one-half hours, when the mixture will be of a dark-amber color. Meanwhile, slake the remaining eight pounds of lime with the salt in another barrel, add water to make about forty to forty-five gallons, turn in the steam, and bring to a moderate heat when the mixture in the first barrel has actually boiled one and one-half hours. Unite the two mixtures, let them boil up together for a few minutes, and you have an almost perfect combination, that sprays evenly and has no uncombined lime or sulphur particles. When this mixture dries on the trees it is of a greenish yellow, not white, and, where it is properly applied, its work is perfect.

An easier way is to dump everything together in one barrel, turn in the hose and let it cook an hour or more, until the mixture is of a brick-red color. By this method there is always some uncombined lime and sulphur, and the material must be carefully strained before it is used.

Hog-scalders are quite generally used where no steam-cooker is available, and they answer their purpose well for the formula recommended above to make 150 gallons of wash. Further details concerning this mixture will be found in Bulletin No. 169.

The effects of this wash on the pernicious scale is peculiar and not yet entirely understood. An examination made in early June of a badly-infested tree sprayed in March, will show under the best covered areas a goodly proportion of plump, full-grown, yellow females, apparently just ready to reproduce. But the date of hatching will come and go and no larvæ appear, though the female adults remain. And this condition continues, the live insects gradually decreasing in

number on a well-sprayed tree, until, late in fall, there are no more to be found. Should the tree be imperfectly or but thinly covered, larvæ will begin to appear late in July or in August, and then the tree may become recovered with a rush, so as to be quite badly infested by October. All the modifications of this material have this same peculiarity, and, in the records of the Experiment Orchard, several examples of it are brought out.

As to the general effect of the mixture, that has been excellent. Peach orchards especially have taken on a new lease of life, and some that were almost given up have been brought back into fairly good condition and fitted to make decent crops.

The great advantage of the material is, that applied even to peach trees, while they are dormant, no harm is done, no matter how recklessly it is applied. Even nursery trees can be safely sprayed with it. One nurseryman who had reason to suspect the source of his buds, sprayed the butts of the budded peach stock by means of a specially designed pair of nozzles and lance that enabled him to cover the entire circumference at once. Not a bud was lost and not a scale was found around any bud when the trees were ready to be sold.

An incidental advantage in the use of this material is the fact that it acts also as a fungicide, and in peach orchards has a tendency to prevent leaf-curl. Apple and pear so sprayed hold their leaves later in fall, and the fruit seems to be less spotted.

Lime, Sulphur and Soda Wash.

The objection most commonly made to the lime, sulphur and salt wash is that it requires so much time and work to make it. Hence there has been an effort to obtain a substitute method by which a chemical combination of lime and sulphur could be formed without the use of outside heat. Experiments made at the New York (Geneva) Station indicated that such a combination could be obtained by using caustic soda, with an excess of lime to combine with the sulphur. The formula was republished in some agricultural papers, and varying reports were made as to the success obtained. I tried to make the combination in a small way and failed; some others of my colleagues failed equally, and the matter was dropped until early fall. The death of Mr. V. H. Lowe, who made the original experiments, delayed somewhat my obtaining details as to the method of making the

combination, but October 6th, Mr. P. J. Parrott, of the New York Station, kindly supplied the information needed. He wrote in effect that the formula used was—

Lime	33 pounds.
Sulphur.	17 pounds.
Caustic soda.	$4\frac{1}{2}$ pounds.
Water	50 gallons.

Slake two-thirds of the lime with water enough to prevent it from burning or drowning. During the process of slaking, add one-half of the sulphur and stir it in. Then add the remainder of the lime, and, as the boiling continues, add and stir in the balance of the sulphur. Add water in small quantities as needed to keep up the slaking, and stir to help the combination of the lime and sulphur. While the mixture is yet steaming, add one-third of the caustic soda, which will cause a violent boiling. Before this is over, add another third of the soda, and add the remainder if the mixture has not yet reached a brick-red color. If too much water is used at the start or during subsequent operations, it may be necessary to use more soda than the formula calls for to ensure the red color of the mixture. This is then diluted to form fifty gallons.

This formula and the directions were closely followed by Mr. Dickerson, who made up the wash at my direction, using lukewarm water throughout. In less than an hour there was half a barrel of steaming wash of a yellowish brick-red. Three hours later the mixture was still hot, and, though it had only half as much water as the formula called for, it could have been sprayed as it was. It was of an even consistency throughout, with only a few little pellets of uncombined lime that could have been easily strained out. Six hours later, or nine hours after it was made, the wash was still warm and had not settled appreciably. Next day—twenty-one hours after the making—there was some sediment which, however, stirred up readily so as to form a sprayable mixture. Spreading out the sediment thinly it was noted that the fibre-like crystals were forming and the combination had begun to break down. Next day there was much more sediment, and many more crystals, and this deterioration continued steadily, though really more slowly than in the boiled mixture.

Mr. A. T. Jordan made up this same mixture at the College Farm in the spring, and found no difficulty either in getting the combina-

tion or in applying it when made. My original failure was due, no doubt, to the small quantity of material used, from which sufficient heat could not be developed to effect the chemical combination.

Even more care is required in obtaining a perfect combination by this method than by the boiling; but it eliminates all apparatus, other than a couple of barrels, in one of which a lot of the wash can be made while that made in the other is being applied.

It will be better to use slightly-warmed water throughout. If very cold water is used slaking will be retarded, and sufficient heat will not be developed to form a food combination of lime and sulphur. The wash will spray better if warm, and, unless chilled by the addition of cold water, will retain its heat for at least three or four hours—long enough, at any rate, to spray it at ease.

Any form of caustic potash or soda may be used. "Washington" lye was used by me and Babbitts' lye by some others. The only point to be noted is that the pound-cans of "lye" contain only about three-quarters of a pound, and therefore a "can" of this material must not be considered as equivalent to a pound requirement in the formula.

As to the effectiveness of this wash opinions differ. Mr. Jordan found that it killed a large percentage of the scales on the trees where it was applied, but enough remained for a reinfestation this fall.

Comparatively few of the New Jersey growers have used the material, and in no case was the result equal to that obtained from the boiled wash. On the other hand, it is probable that the combination was not as thorough as it should have been.

Mr. Marlatt considers the method a very slack one, and doubts whether it results in as efficacious a product as that secured by steam boiling.

Mr. Parrott, who was good enough to send me the detailed directions for making the wash, writes: "I do not feel that it is as efficient as the lime-salt-sulphur wash, or will take its place for the treatment of large orchards. The preparation of the wash with the soda, in place of the steam or fire, seems to appeal especially to owners of small orchards, and a number have used it, with satisfactory results, and are going to use it in the future. I really believe that the trouble of preparing the sulphur with lime has been greatly exaggerated, and orchardists will find it so as they become experienced in preparing and applying it. I regard the soda-sulphur spray as entirely in the experimental stage, and, until severe tests have been made, I shall continue to advise the use of the ordinary lime-salt-sulphur wash."

That is the condition of affairs at the end of the season of 1903. Experiments will be made extensively during the winter and spring of 1903–1904, and next fall the place for this wash will be more definitely known.

Calcothion.

Experiments with this material were continued, but in a way they were not fair tests of its value. A supply was obtained early in the winter and was allowed to stand until March before use. Two applications were made—one March 4th, on a clear, sunny morning, while the ground was frozen; the other March 13th, under similar weather conditions. From long standing the mixture had settled, and sulphur crystals had formed in considerable quantity. These did not yield to moderate heating, and were strained out before the mixture was sprayed on. The mixture adhered well, but the effects were irregular, as will appear in the record of the Experiment Orchard.

On the other hand, I have several records from orchardists who used the material with very satisfactory results. The indication is that the mixture must be used within a reasonable time after it is made, and that, on long standing, the combination of the sulphur and lime breaks up or changes in character.

This feature was even more emphasized when I attempted to use a concentrated mixture, which was suggested to save freight. If a gallon of concentrate could be made to give four gallons of wash, or even two and a half, there would be distinct saving to the consumer in cost of transportation, handling and receptacles. So a small lot of material was sent to me, to be diluted with three parts of water, and another to be diluted with one and one-half parts of water. Both of these lots were also kept standing for two or three months, and when opened a thick mass of sediment was found. This was broken up and hot water was added, according to directions. But when I attempted to spray, crystals formed so suddenly that the pumps went out of service on the instant and the hose was filled with spicules of lime and sulphur.

It is known to all who have used the boiled lime, salt and sulphur wash that, if it is allowed to get cold and settle over night, it cannot be used next day, and that renewed boiling will not renew the wash.

Concentrated Sulphides.

On the theory that it is the caustic sulphide of lime that is the really effective feature of the lime, salt and sulphur wash, it would seem that concentrated sulphides, soluble in water, might be equally effective. So the Adler Color and Chemical Company sent me for trial a can of concentrated sulphide salts. I used it on some of the trees of the Experiment Orchard (1, 4, 5, 27 and 28), and while it is a horribly caustic material—even the smallest drop burning into the skin—the effect upon the scales was slight. The salt was used at the rate of one pound in one gallon of water, and apparently caused no injury to the tree, nor to the fruit buds of peach and plum. Details as to the conditions under which the applications were made will be found in the Records of the Experiment Orchard.

RECORDS OF THE EXPERIMENT ORCHARD.

There have been sad changes in the composition of this little gathering of trees, each of which has taught a lesson ere it died. The increased size of the trees of itself necessitated a reduction in their number. The fact that others, having reached bearing age, attracted the attention of the hoodlum element, and required constant watching, made their removal a matter of policy, if not of necessity.

Only part of the gaps so made have been filled, and some gaps will remain, though the original numbering is retained.

The record begins with January 1st, 1903, which was a bright, cold day, when all save Nos. 4, 32 and 36 were pruned. No. 44 was marked as a dying tree, and sharply cut back; but left to see what it would do. Later it was decided to take it out.

February 26th was a bright, sunny day, which started the snow then on the ground to the melting point. Sprayed trees 1, 4, 5, 27 and 28 with the concentrated sulphide salts sent in by the Adler Color and Chemical Company, at the rate of one pound in one gallon of water. Trees Nos. 7 and 28 each received about a gallon of the mixture and were thoroughly wet down. Tree 4 received one and one-third gallons. The other sprayed trees took up the balance of a five-gallon total. Where this mixture hit the hands every droplet burnt, and, if it is ever to be used practically, spraying must be done so as to avoid hitting men or animals. On the evening of the 27th

it began to rain, the temperature rose, and by the morning of the 28th practically all the snow was gone. Average storm temperature was about 60°, and there could be little of the soluble sulphide salt remaining when the rain ceased.

March 3d, tried to apply some af the concentrated lime, sulphur and salt mixture sent by the Adler Color and Chemical Company, beginning with that which was to be diluted with three times its bulk of water. A very solid cake had settled at the bottom, and, when this was broken up and hot water added, it looked as though it might spray. Used the Nixon pump, with Bordeaux nozzle, and managed to get over tree 2 and part of tree 8 before everything set solid. Took the pump apart, washed it out, and tried a bucket pump. This lasted half a dozen strokes, and went out of service. By this time the mixture was a mass of crystals, and I gave it up.

Tried the next combination, which was to be diluted with one and one-half times its own bulk of hot water. This worked a little better at first, but before tree 8 was completed the strainer had to be cleaned two or three times. A new lot was then mixed up, and a coarse sacking was put below the strainer to keep it clean. This was even worse, because the crystals choked the sacking and nothing got to the pump. As a last resort took off the strainer altogether and changed the nozzle to a solid jet. In this way I managed to complete trees 9 and 40, and that ended the matter—pump and all.

March 4th was a clear, sunny morning, the top of the ground lightly frozen. Applied the normal Calcothion, just as received in early winter, with a Leggett compressed air sprayer, through a Vermorel nozzle, on all trees not already sprayed and not covered by the cages. There was a little sediment in the barrel, but it went into suspension readily on stirring. As there were some of the sulphur crystals present, I strained the mixture into the spray bucket and found no trouble. When dry the trees had a peculiar bluish tint, as though there was copper in the mixture. I noted, also, that while the body and main portion of the tree were fully coated, the terminal shoots left something to be desired.

March 13th, applied a second coating of Calcothion as completely as possible and found, when it dried, that everything except the extreme tips were fully covered. Photographs were made showing the appearance of the trees at this time.* The weather at this time was

*Negatives and prints from them were destroyed in the Laboratory fire.

warm and dry and continued so until the evening of the 16th, when a Scotch mist covered everything, but did not drop much water.

The season opened early, and everything was leafing out late in March. On the night of April 4th–5th there was a heavy frost, the thermometer on my front porch registering 28° at 7:30 A. M., and the mosquito pails showing nearly one-half an inch of ice. Next night was nearly as cold, and frost was in the ground one and one-half inches when I dug a hole for tree 42. Blossoms were out on trees 4 and 25, and some of these turned black, while the shoots of rose and lilac were killed back severely. As the cold moderated, it began to rain on the afternoon of the 6th and continued during the 7th and 8th, opening clear and cool on the morning of the 9th. The temperature remained low, and rain began falling again on the evening of the 11th, continued all day the 12th and developed into a heavy northeaster, lasting all day the 13th and 14th. It moderated on the 15th, but did not clear until the 16th. Some of the trees were out in bloom at this time and some came out during a period of cool weather, in which the thermometer did not get above a night temperature of 40°. On the 27th it began to warm up, and on the 29th it was positively hot, and a period of drought began which lasted for over a month. A temperature of 90° was reached before the 20th of May and everything suffered for want of water, though the garden hose was kept going more or less continually.

Little was done during the summer save to make occasional notes of conditions, but on September 6th things were so bad that I deemed it wise to spray trees 1, 2, 5 and 8 with fir-tree-oil soap, at the rate of one pound in two gallons. The effect was excellent and the supply of young scales was materially reduced in each case.

September 16th, there was a terrific storm that loosened every tree on the place and whipped the leaves on some of them to shreds. Practically all that was left in the way of fruit was blown down.

On the whole this was a very unsatisfactory season for orchard fruits, except apples, though my peaches did all that could be expected of them.

Special records are as follows:

TREE 1—*Mariana Plum*. Received an application of the concentrated sulphide salts February 26th. Made a start about the middle of March, and on the 24th was full of buds, some of which already showed white. A few had opened before the frost, and by April 11th the twigs were ropes of white blossoms, though not until the 17th was it in full bloom; some of the flowers black at the heart. There

was the indication of a heavy fruit set, but nearly everything dropped before June. On the 22d of that month the trunk and inside of the tree seemed to be practically free from live scale, but on last year's growth larvæ were crawling in numbers and new sets covered the shoots. The brood was a very heavy one for the first, and would seem to indicate that the sulphide application had been useless. Whether it could have done better had it not washed off so soon is perhaps a question.

July 23d, the tree was in good condition, and the few remaining fruits began to color up. The scale situation was not so bad as was indicated earlier and some larvæ were about, but there was nothing serious. The fruits disappeared as they ripened and scale continued to breed until September 6th, though the trunk and older wood was in good condition and practically free, the newer shoots were in some places fairly coated and larvæ were swarming. On that day sprayed thoroughly with fir-tree-oil soap at the rate of one pound in two gallons of water, and this seemed to have been very effective.

On September 20th not a sound leaf remained on the tree, the storm of the 16th having whipped the little twigs so as to almost tear the foliage to shreds. A few scale larvæ were seen at this time and some recent sets, but things were so much better that I intended to make another application. Weather conditions and other things prevented, and on October 20th everything seemed dormant. There were plenty of living scales in some places, and over these, specimens of *Aphelinus fuscipennis,* the little wasp-like parasite, were hunting about, apparently laying eggs.

The fir-tree-oil soap mentioned here is part of a lot received for trial two or three years ago. I have used of it from time to time to kill plant lice and always with good effect. This is the first time I used it as against the pernicious scale, and it is more effective than whale-oil soap. It does not kill the old scales, but it does kill all moving larvæ and all white sets. It will not prevent larvæ hatched after it has dried from setting, but it has seemed to me that there were fewer sets on the places most thoroughly sprayed, the larvæ preferring to move out on the new growth.

Tree 2—*Yellow Transparent Apple.* This was sprayed March 3d with the concentrated lime, salt and sulphur mixture, as referred to in the general notes. On the 24th the tree was yet quite white except at the tips of the shoots, but there was also plenty of live scale. April 17th, the tree began to start, and on the 29th was leafing out fairly.

A few blossom clusters developed, but no fruit set. June 22d, the tree was in full foliage, looked healthy and very clean, and there had been no extensive scale breeding. There was quite an infestation of plant lice at the tips of some shoots, and the honey-dew, with its accompaniment of black soot fungus, was somewhat disfiguring. Syrphid larvæ were at work among the plant lice, many of which were also dying as the result of some disease, which turned them dull brown in color. The growth was good early in the season, but had stopped July 23d, when the foliage showed the effects of leaf-hopper attack. A month later this injury was intensified, the leaves were yellow and some had already fallen. A new brood of scales was just setting and moving well out on the new shoots. The tips of some of the fruit spurs and the bases of the leaves were, indeed, the worst infested regions, as the trunk and old wood showed only a slight setting. September 6th, gave an imperfect spraying with fir-tree-oil soap, one pound in about two gallons of water, and on the 20th found that new hosts were again crawling about and demanding treatment, which was not given. The foliage was already lifeless and considerable was gone, but this was, at least, in part, due to the storm of the 16th. October 20th the foliage was nearly all off and the remainder dropped at a touch. Scale extends to the ends of the new growth, but seems to be done breeding and is not a serious menace to the tree.

The winter treatment seems to have had little effect; but, as already stated, the material had completely changed in character, and it is probable that little more than a lime wash really reached the tree. It is not fair to judge the concentrated mixture from the sample which was allowed to stand so long.

TREE 3—*Black Tartarian Cherry.* This tree has never had more than a few accidental scales, and is no worse this year than at any previous time. It has grown well throughout the season, has had a slight dose of plant lice and a little attack of slug; otherwise there were no adverse conditions until the September storm, which tore the foliage into shreds. Whatever fruit set was taken by the robins long before it was fit to eat. Late in October the foliage was almost all gone, after a frosty night or two, and fruit buds promised a heavy crop for the 1904 birds.

TREE 4—*Abundance Plum.* This was a very scaly tree, and was sprayed February 26th with the concentrated sulphide salts, one pound in one gallon of water. It made a start March 24th, when it promised a heavy bloom, although two branches appeared to be dead.

It blossomed in due course, but no fruit set, and ever more of the tree died down, until in mid-June more than half was gone. At that time there was a heavy brood of larva and everything alive was being plastered up. August 24th the tree was a sight. More than half dead, dead leaves all over, yet the remaining shoots making a brave fight. Scale everywhere and along every vein of every leaf. So completely were the branches coated that there was no room for new sets, and larvæ were so numerous that they were noticeable fifteen feet away, as if the tree had been pollen dusted. It was an interesting sight, but the conditions demanded prompt action and the tree was cut down. The winter application was a complete failure, and, practically, the scale developed unchecked. It is the first instance that came under my observation where a tree was so completely coated that there was literally no chance for the developing larvæ to find a place to set.

October 28th, set a dwarfed Duchesse pear started for trellising; it is an imported stock, which has grown one year year in New Jersey, and became moderately scale-infested here.

Tree 5—*Bartlett Pear.* This was sprayed February 26th with the concentrated sulphide salt solution, one pound in one gallon of water, and seems to have received, also, at least a partial spraying with Calcothion. March 24th, the tree showed an obvious start, but not until April 17th were the buds really ready to open. At this time the condition of the tree presented itself strongly: undersized, twisted, the trunk marked by sinuate borer, and partly dead from body blight. But it showed life, and was allowed to go on. May 19th, it was not only in full foliage, but some shoots had already stopped growth; there were a few fruits set, but their appearance was not encouraging. June 22d, conditions were even worse: some of the shoots were infested by plant lice, pear slugs were on the leaves, and a healthy brood of scale larva was making its way to the new growth. A month later a new start had been made, and a new growth was making; but by this time the older foliage was pretty well scraped up by slugs, and the eight developing fruits were scale infested. August 24th, the second growth had also ceased; scale was worse than ever, and the injuries to the trunk seemed more serious than before. The fruits, six in number, were taken off. September 1st, fully ripe, undersized, though of good flavor. September 6th, while the tree was full of larvæ, sprayed thoroughly with the fir-tree-oil soap, one pound in

two gallons of water. An hour later the effect was quite marked—all larvæ and recent sets appearing to be dead or dying. On the 20th more than half of the foliage was off; the scale situation was much improved, though there were some larvæ moving about. The injury to the trunk over the burrow of the sinuate borer had become so very marked that I concluded that no satisfactory tree could be developed, and I had the thing cut down. This was not replaced.

TREE 6—*Greensborough Peach.* This received in course, and not because it was needful, a coating of Calcothion March 4th. It began starting on the 24th of that month, but not until the middle of April were the blossoms out in full and the leaf buds opening out. May 19th, was growing well, but some of the leaves were curling, under a plant louse attack, along the mid-rib. June 22d, it was not noticeably scaly, but on July 23d there was a scattering throughout the tree. Evidently this was a good ground for the insect, because, August 24th, there was a great deal of scale—a new brood just moving and most of it getting out on the new shoots. On some leaves even quite a bit had set along the mid-rib. October 20th, the surface of the older wood was almost completely covered with scale, and the infestation extends on the new growth to the tips, heaviest, indeed, at the tips and around the buds. There had been one borer in the tree, but this was now gone. This affords an excellent illustration of the manner in which an infestation coming on a clean tree may completely cover it in even a single season. Nothing has been done to check the breeding, but there are some specimens of *Pentilia* on the trunk which have undoubtedly done their share in holding it back.

TREE 7—*Champion Peach.* Received the normal Calcothion mixture March 4th, in due course. March 24th, the blossom buds were ready to open, but not until April 15th was the tree in full bloom; few living scales, except at the tips. Was out of bloom and leafing out nicely May 1st. May 19th, was in full foliage, but looked ragged; some dead shoots. On the whole, in very fair shape. The trunk and larger branches were clean, and a very fair set of fruit had fixed. Plant lice were abundant at this time, and the leaves were more or less obviously curled. A very fair set of fruit had made June 22d, but there was no scale breeding, and no appearance that there had been any. The fruit developed nicely, and began coloring up July 23d. As some of it overhung the fence on Senior street, all the peaches on that side were taken off and the branches cut back. Never-

theless, raids were made by some of the hoodlums, and the fruit was, most of it, taken off before it was entirely ripe. It was all off by August 24th, at which time the tree looked somewhat ragged. Very little scale had developed. There was a scattering on the new shoots, there were no larvæ or recent sets, and, in some parts, the tree was entirely clean. The storm of September 16th whipped the foliage badly and loosened the tree so much that I was able to slant it well away from the fence when firming the soil around it. October 20th, very little of it stripped easy. A good set of fruit buds was making, and there seems no apparent reason why there should not be a heavy crop for 1904. There is very little scale on the old wood and not very much on the new. Quite a number of *Pentilia* were moving along the branches. What fruit developed on this tree was excellent in size and quality, and, had it been possible to allow all to remain on, it would have been satisfactory in quantity. The situation close to the fence along the street line made the attempt to preserve the crop cost more than it was worth. The tree was not very badly infested last fall, but is in better condition in all ways than it was at that time.

TREE 8—*Grimes' Golden Pippin.* Sprayed March 2d with the concentrated lime, salt and sulphur mixture. On the 24th most of the scale appeared to be yet alive, and in some places the coating was complete to the tips of the twigs. It began leafing out about the middle of April, and was in pretty fair foliage on the 29th of that month, but there was no appearance of bloom and some twigs were dead. There was plenty of live scale, and yet there appeared to be less than there was a month previously. On the trunk and larger branches the scaly crust seemed to lift off very easily. Further improvement was noted May 19th on the older wood, but dying from the tips seemed yet to continue.

Up to June 22d no scale larvæ had developed, and there was no appearance of any recent sets on the tree. It was in full foliage, and, as a whole, looked healthy; but there were two species of plant lice at the tips of the shoots, and leaf-hoppers were becoming obvious. July 23d, had made a very fair growth, and some shoots were yet growing. On the trunk and older wood the scale covering had peeled off in great flakes, and most of what remained was dead and dry; but on the outer shoots a brood had developed which had extended even to the leaves. August 24th, all growth had stopped, and the foliage was quite yellowish, as the result of leaf-hopper attack. A

new brood of larvæ was moving, and the leaves and outer shoots were getting to be quite well plastered up. September 6th, sprayed with fir-tree-oil soap, about one pound in two gallons, and drenched rather thoroughly. An hour later there were many dead and discolored larvæ and recent sets; but there were, also, quite a number of new larvæ, evidently born since the application had been made. The tree was badly whipped, and lost some of its foliage, in the storm. Some of the remaining leaves were scalded, as if the soap had been too much for them. October 20th, the upper part of the tree was almost completely scale-coated, so that not even a sign of bark was visible. Larvæ were yet moving, and recent sets were abundant. The tree seems to be making an effort to develop fruit spurs, but they are very much held back by the insects. There are not so many *Pentilia* as might be expected from the infestation, and this leads to the note that the little beetle is much more abundant on peach than on any other of the fruit trees.

This tree should have been sprayed during the early summer and was slated for such treatment; but, except for the early September application, none was made. The difficulty with the concentrated lime wash has been already detailed in the introductory notes, and, from the fact that the older wood seemed almost clean during the summer, it is not unlikely that, could the wash have been put on more evenly, the results would have been better.

Tree 9—*Champion Peach*. Sprayed March 3d with the concentrated lime, salt and sulphur wash, getting on a thick, though somewhat imperfect coating. Made a start March 24th and was in full bloom April 11th. On the 29th the blossoms were about gone and the foliage was making fast. Some few dead tips showed as the season advanced, but these were as nothing to the healthy shoots making from the old wood. The fruit set was very heavy, but as the tree was in the fence corner, exposed to foragers, all of it was taken off before the end of July. There was no scale breeding at all during June, though there were living females that had hibernated, and up to the end of July very few larvæ developed. At the August 24th examination I noted that "the almost complete absence of scale is remarkable." September 6th, though the tree was in excellent shape I directed its removal because of its location and the temptation that the fruit offered to boys thievishly inclined. It is simply impossible to carry on any experiment that involves ripening fruit without a guard to keep off those that do not consider fruit as personal property.

The interesting point in this tree is that the same material which failed with tree 8 gave an almost perfect result here, and, though the former was a little the worse infested, this latter was also bad enough for practical purposes. In both trees breeding was delayed until the end of June, fully two weeks after larvæ were plentiful on some others. It is not intended to replace a tree with this number.

Tree 10—*Greensborough Peach.* This was set out of line as a substitute for No. 9, when that should be taken out. It was clean when set, became somewhat infested during the summer of 1902, and received the Calcothion applications in due course. It started late in March, blossomed sparsely, leafed out normally and grew well, but set no fruit. A little scattering of scale was noticeable late in July, which had increased somewhat a month later, the insects being then about full-grown. A brood of larvæ developed in early September and worked out toward the tips. October 20th, the record was that the tree had made rather a straggling growth and was ill-shaped. Fruit buds were setting well, while foliage was good as to appearance and sticking qualities. There was considerable scale infestation on the new growth, but very little on the trunk. It seems probable that a large percentage of the infestation came from tree 8 because so much of it is well outward at or near the tips, and even on the leaves.

Trees 11, 12 and 13 are out.

Tree 14—*Seckel Pear.* This became so surrounded by the growth of blackberry shoots that it was overlooked at the first spraying, and received only the second Calcothion application. There was only a scant growth made during the season and that seemed scarcely healthy. On the other hand, though there seemed to be a good percentage of live scales in early spring, these gradually died off without reproducing their kind, and left a practically clean tree in early September. I could not see any probability of getting anything more than a cripple out of it, and had the tree cut down in September.

Tree 15—*Japan Golden Russet Pear.* This received the two Calcothion sprayings in due course, and before the end of March the flower buds began to burst their envelopes. The frost of mid-April hit some of the bloom, but not until the 29th were all the buds open and the leaves unfolding. May 19th, had made a very heavy set and was in full foliage. Growth continued until well along in July, when the fruit began to crack and pear slugs became obvious on the foliage. By the end of August the fruit was half-grown; some of it was wormy, more of it was cracked and only a little was really fine. The

storm of September 16th blew off most of the pears, tore the tree from its fastenings and switched the foliage to such an extent that the balance of the fruit was taken off to facilitate tying up again. October 20th, a goodly part of the foliage was gone and much of the balance was ready to fall. The set of fruit spurs for 1904 promises a smaller bloom than ever before in the history of this tree. Throughout the season there was a scattering of live scale on the tree, but at no time was there any obvious brood of larvæ. So, even at the last record, October 20th, there was not enough to indicate that winter treatment would be necessary or even desirable—just a little setting here and there.

TREE 16—*Japan Golden Russet Pear*. As a whole, the history of this tree agrees with that of No. 15. It is less vigorous, however, and bore a smaller crop. The fruit was better, though, and not so wormy, nor did it crack so much. More fruit spurs have gone out of service than have been replaced, and, on the whole, the promise is for much less in the future than has been done in the past. As to the scale, that is rather more plentiful than it is on tree 15, but yet not enough to be in any way injurious.

TREE 17—*Keiffer Pear*. The tree received the two Calcothion treatments during the winter. Began to start March 24th, but the blossom buds were few in number and feeble in appearance. April 20th, the foliage was developing evenly and the bloom was out full—which was a scant showing at best. Some of the flowers seemed frost bitten, others appeared as though they had been eaten into, and yet others seemed crippled. Few were normal in appearance. As the season advanced conditions became worse, instead of better—very little fruit set, and this developing slowly; scanty, undersized foliage, turning yellow; a large blighted area on the trunk, indicating the real seat of the trouble. The half a dozen fruits ripened and were taken off just before the September storm. As to scale, there was very little at any time, and at no time until September were any moving larvæ seen. Plant lice were a little troublesome early in the summer, and slugs scraped the thin foliage prettly badly in midsummer.

As the tree was of no use in its then condition, and nothing was to be gained by holding it, it was ordered out September 18th.

October 27th, set a peach which had been grown for trellising in Europe; had remained in an exposed situation during the summer, and had become somewhat scaly in consequence.

Tree 18—*Keiffer Pear.* Was twice sprayed, in due course, with Calcothion, and began a slow start March 24th. A month later all the foliage was developing, and there was a scant bloom. For some reason most of the buds turned brown and died, so that not more than a fraction of 1 per cent. ever opened. There was no set at all, and not a pear developed. The foliage throughout the season appeared to be sickly—was small in size, light in color, and in no way what it should have been for this variety. October 20th, the foliage was more than half off, and the balance was ready to go at a touch. A heavy development of new fruit spurs promises a profuse bloom for 1904. The injury done by the sinuate borer is more strongly marked than before; but no new galleries are noticeable, and there is no hole indicating that any beetle has issued this year.

As to the scale, there never was, at any time during the season, more than a scattering, and when the examination was made, October 20th, such scales as were examined had no living thing underneath. At no time were larvæ observed, and only twice was there any appearance of recent scale.

Tree 19—*Keiffer Pear.* Received the two applications of Calcothion March 4th and 13th. On the 24th the lime wash was flaking off, taking the scale along. Leaf buds began to start all over the tree April 17th, but only a few blossom clusters showed any signs of development. The great majority did nothing whatever. Of the scant bloom only two flowers set fruit, and these ripened September 6th and 20th, respectively. They were Keiffer hard and Bartlett texture. Had it not been that Keiffers set poorly almost everywhere, I would have been inclined to suspect the Calcothion of some share in the blasting of the fruit spurs. The spurs for 1904 are scant for this variety.

One point to be noticed in connection with the pear trees this year is the entire absence of the pear midge. With so scant a set it might have been expected that all the fruits would be attacked; but, as a matter of fact, not an infested fruit was seen.

As to scale, there had been a slight development June 22d, and at the base of last season's growth there were many live, full-grown females. Nevertheless, as late as August 24th there was only a mere scattering, and none on the fruits. But in September conditions changed, and, on October 20th, some of the small branches were pretty well coated, and specimens of *Aphelinus* were found running about among them in small numbers.

TREE 20—*Meech Quince.* Received the two sprayings with Calcothion in March and began to point out on the 24th of that month. Was in full leaf April 29th and in full bloom May 10th. June 22d, some twig blight had developed and was cut out; most of the tips were more or less infested by plant lice, and the pear slug was present on the foliage in some number. With the coming in of the rains the tree started a new growth, set a few more fruits from new blossoms and by the end of July had a very decent little crop under way. Nearly all of this fruit was blown off September 16th, but a few little ones remained, and on November 10th there was yet one left, less than half-grown. The foliage was then nearly intact, the plant lice and slug injury being still noticeable.

As to scale, there was a little of it found at all times when examinations were made, but not more in October than in June, and this point accords with numerous orchard observations. Quince trees, while they support the scale, do not offer a favorable ground for its development, and need not be kept under close observation. I have found no exceptions to this, yet I would not like to say that there are none and that quinces are never injured by the pernicious scale.

TREE 21—*Keiffer Pear.* Received the two sprayings of Calcothion in March, and on the 24th of that month blossom buds began to separate. A month later the tree was in full foliage, and also in full bloom, if that term can be used for the few flower clusters that actually opened out. No fruit was set. As a consequence of sinuate borer injury, some of the lowest branchings began to die off and were cut out. June 22d, this was the most vigorous tree of the series, and scale-breeding had begun from the sets at the base of last year's growth. There was less slug than on the other trees and less plant louse attack. Growth stopped about the middle of July, but scale-breeding continued throughout the season in a small way until October 20th there was rather a severe infestation toward the center, but no larvæ or recent sets were seen. No parasites and no predatory species were noted. As to the tree itself half the foliage was off, the growth in general had been good, and the set of fruit spurs was very heavy.

TREE 22—*Japan Chestnut.* Was sprayed with the Calcothion mixture early in March, and the effect, as noted on the 24th of that month, seemed to be to take off a little surface film from the bark. The tree grew well during the season, blossomed heavily, but made no set. It was somewhat loosened in the September storm, but was

straightened and repacked next day. On October 20th it was yet in almost full foliage, seemed to be in good general condition, but was straggling and not a good-shaped tree.

As to scale, there was a little at all times, but I could not find that there had been any breeding, and it seemed, rather, as though larvæ had come on from the outside, set, reached half growth and then stopped further development. There was not, as a matter of fact, more scale in October than there had been the preceding March. This accords with my orchard and nursery observations, in which I never found a badly-infested chestnut, though it is not unusual to find a few scales where the surroundings are bad.

Tree 23—*Greensborough Peach.* Was rather carelessly sprayed with Calcothion in early March, made a little bloom later, and, on April 17th, made a very fair show with its large, wide-opened flowers. Several fruits set, but dropped, and thereafter the tree grew undisturbed until well along in August. The storm of September 16th loosened it a little and gave the foliage a ragged appearance, but on October 20th it was yet in almost full leaf. Aside from a somewhat irregular shape there is no fault to be found, and fruit buds have made in good shape.

A little scale came on this tree in 1902, and this seemed to be alive in May. But at no time during the season did I notice any breeding, and at the October examination there was only a small infestation present.

Tree 24—*Greensborough Peach.* Was very thoroughly sprayed with Calcothion in early March. It made a start before the end of that month and by the middle of April had opened a nice little lot of large, showy flowers, none of which set any fruit. In its record of growth and final condition it is a repetition of tree 23. So the scale situation is also similar, except that on August 24th I found a small lot of recent sets on the new wood in such position that it is certain that they came on from an outside source.

The irregular growth noted in this and the preceding seems to be a characteristic of the variety.

Tree 25—*Apricot.* Received the usual Calcothion mixture, and it looked, early in the season, as though there might be some bloom; but by the end of April it was in full leaf, and not more than half a dozen flowers had been open—none of which set any fruit. Throughout the season, and until late in August, growth continued, and the tree has now covered practically all its trellis. The September storm

whipped the upright shoots sadly and tore the leaves on them; but as late as October 30th the foliage was yet intact as a whole and not ready to drop.

At no time was there much scale on the tree, and in October there was not enough to indicate the desirability of making winter application. This is another of those trees that maintain themselves as against this insect, and it is unfortunate that it does not fruit well with us.

TREE 26—*Nectarine.* This tree was sprayed in March, partly with the concentrated sulphides and partly with the Calcothion, neither application being a very thorough one. The foliage came out well, but there was only one blossom, at the extreme end of one twig, and this set no fruit. June 22d, some plant lice were noted. Growth stopped in early August, and was all that could be asked. The foliage continued nice and clean until it was torn by the September storm. Scattering scales were on the tree throughout the season, and some infestation appeared on the new wood; but though apparently full-grown females were seen in some number August 24th, I could not find that there had been any larvæ or recent sets in early September.

October 20th, the tree was in very nice shape; the foliage ragged, yet practically complete and adhering firmly. A little, scattering scale infestation, but nothing to really demand treatment.

TREE 27—*Cratægus.* This received an application of the concentrated sulphides from one side only, and, on March 24th, it seemed that, as compared with the unsprayed side, the treated area was made cleaner. At all events, there were plenty of living scales. The foliage came out normally, and had reached its full growth by the end of July. The shrub was always subject to plant lice attack, and as early as mid-June hosts of them infested and curled up the tips. The usual soot fungus developed, and gave everything an unattractive, dirty appearance.

Scale began breeding before June 15th, and on the 22d of that month there was already a heavy set of young. A month later another lot of larvæ was afoot, and the plant lice had stunted and dwarfed the foliage. August 24th, some of the shoots began to die, and as, with scales and plant lice, the plant was failing, I had it taken out in September, on the 6th of which month everything was yellow with moving young scale.

This plant really served no good purpose, except to show how badly it could become infested by scale and how much it was subject to

plant louse attack. It was almost cleaned on two or three occasions, but always became coated again the season following. It also furnished another example of the ineffectiveness of the concentrated sulphides.

Tree 28—*Early Michigan Peach.* Was thoroughly sprayed with the concentrated sulphides February 26th, all parts of the tree being drenched, because there was a considerable scale infestation. In trimming I had cut away pretty well from one side, because it leaned over into the next lot, and this left a lop-sided appearance. March 24th, noted a start in growth, and also that there were many apparently healthy scales on the tree. At some points on the trunk there seemed to have been a washing off, and there the bark looked clean and polished, but, as a whole, there had been little reduction in the infestation. By the middle of April the tree was in full bloom, and on the 19th this was going out, as the leaves came in. Was in full leaf May 1st, and had set plenty of fruit for a full crop. Up to the middle of the month the foliage seemed unhealthy—many of the leaves were curled by plant lice—and altogether the tree looked ill. June 22d, this unhealthy appearance was gone, but there was a heavy brood of scale larvæ, which spread everywhere. July 23d, the scale had increased to such an extent that some twigs began to die. The fruit was developing normally, but as it was too attractive in full view of the street, I ordered it removed to discourage raids. August 24th, the dead wood had increased in amount, and so had the scale. Two peaches had been overlooked, and these I took down, fully ripe, of good size and excellent in quality. September 20th, I decided that it would not be worth while to keep the tree if I could not get its fruit, and therefore ordered it out. The sulphides were certainly a failure here, though the application was as thorough as I could make it.

Tree 29—*Gravenstein Apple.* This tree had the two applications of Calcothion in March. By the end of that month, though it had made no start, the effect of the wash was seen on the strawberry plants which, being beneath the tree, had received their share of the application. Much of the foliage was distinctly dry, and some of the new leaves were obviously scalded at the edges. Not until the middle of April did the tree make a start, and not until the beginning of May was it in full leaf. No blossoms developed, and, of course, no fruit set. The tree grew well until nearly the middle of August, and then began forming fruit spurs which were in good condition and satisfac-

tory number on October 20th, when more than half the foliage was off and the balance was ready to drop at a touch. Plant lice became obvious almost as soon as the foliage was at all developed, and before the end of May there was some curling of the tips. Toward the end of June the woolly louse made its appearance in appreciable numbers and was readily seen at several points on the tree. Leaf-hoppers also were in some numbers, and the little yellow dots caused by their sucking were quite perceptible. This feature became more obvious as the season advanced, until in September the foliage had a distinctly yellow tinge. The storm of early September loosened the tree so that it had to be straightened and the soil packed around it, and much of the foliage on the northeast side was torn, but, on the whole, it got through very well.

As to scale, there was a little found near the tips of the new shoots June 22d, and this may have been due to a sparse breeding from the hibernating specimens. There was no very marked increase in July or August, and on the October 20th examination there was practically nothing on the trunk and older wood and not much on the new wood, extending, however, pretty close to the tip of the new growth. There was not at any time a sufficient number to require treatment. The condition noted here—that is, the practical freedom of the old wood with a moderate infestation of the outer shoots—is quite a usual result of the lime-sulphur-salt wash. For some reason the surfaces that have received this application seem to be distasteful to the larval scales, and they make their way to the leaves, the fruit and the new shoots, but always in small numbers and for some reason with lowered vitality. The tree here recorded is the best and sturdiest on the place, and, while it has had neither bloom nor fruit to date, it bids fair to make up for lost time next year if fruit spur development is to relied upon.

TREE 30—*Grimes' Golden Pippin.* Was sprayed twice with the Calcothion in March, as recorded in the general notes. Not until the end of April did it make a rather even start and not until the beginning of May were there any blossoms. Only a few of these had set fruits May 19th, and when the crop was harvested, September 20th, it consisted of one very good apple. The original growth on the tree stopped late in July, but was started anew by the middle of August and continued to the beginning of September. A brood of the yellow-necked caterpillar played havoc with the foliage in one section during

early September, but in late October what foliage was left from this attack still adhered quite firmly and the tree was in excellent condition, having formed, also, a rather scant set of fruit spurs.

This tree is one that has always been subject to plant louse attack, and on June 22d there were plenty of the aphids at the ends of the shoots, curling up the foliage. July 23d, some of the tips infested by the lice had died off, partly from the direct drain, partly from the fungus that developed on the honey-dew. Woolly louse became evident in July, and more or less of it was present at all the examinations made, but there was at no time enough to be considered troublesome.

Scale was present on the tree early in the season, but not in any large amount, and up to July 23d there was a mere trace of new sets. A month later matters were not much if any worse, and no breeding was noted in September. October 20th, all the scale on the old wood seemed to be dead, while there was a little on the new shoots, especially towards the tips.

This tree has always been a good subject for insect attack of all kinds. If there are any plant lice at all they are to be found here, and, in a way, this season was no exception. But in September tree crickets were feeding upon them in some numbers, and, in late October, much to my surprise, there was no appearance of the sexed individuals, and no eggs were discoverable.

Leaf-hoppers were present almost from the beginning, and the spots on the leaves were already obvious late in June. Before September every leaf was a mass of yellow speckles; yet it may be questioned whether any real harm was done to the tree. The scale injury during the season was not serious, and may be entirely ignored; yet it would be unsafe to allow the insects to develop, without some attempt to check them, during the present winter.

Tree 31—*German Prune.* Received the Calcothion wash applied to the other trees in March, and began its season early in April, when leaf buds were pointing out all over the tree. Not until the end of April, however, did these buds open, and then, also, a scanty bloom appeared. Plant lice came in early June, and continued until late July, when the shoots stopped growing. The soot fungus, which developed on the honey-dew, lasted much longer, and remnants were seen until September. Three fruits matured early in that month, and were of good size and flavor. The storm of September 16th tore the foliage sadly and loosened the tree, but it was straightened out and looked fairly well as late as October 30th. The growth made

was of the usual lanky pattern, and the tree, as a whole, had no respectable form. Plant lice were plentiful early in the season, and they checked the growth of some of the shoots, but they disappeared late in July, leaving only the honey-dew, with its sooty accompaniment, as a mark of their visitation.

There was no appearance of scale breeding until late in July, and very little even then. October 20th, when the last systematic inspection was made, the old wood was rather badly spattered with scale, but it was mostly dry and dead. There had been some splitting of the bark, and new tissue was forming there; but on the new growth there was not enough to be worthy of treatment, so far as its menace to the tree was concerned.

TREE 32—*Lawrence Pear.* As it was covered to secure the Chinese Coccinellids, this tree received no winter treatment of any kind. March 24th, it was fully coated with scale. Three of the Coccinellids were visible, one of them obviously feeding on the scales. A very irregular condition of development appeared: some leaf buds were pointing out from the lower parts of the branches and a few blossom buds were noted as developing well outward. April 17th, there were two blossom clusters, and the tree was developing very nicely, considering its scaly condition. On the 23d the cage was recovered with wire netting, as the old was thoroughly rusted out. On the 23d only one beetle could be seen. June 22d, the tree was in tolerably healthly condition, all things considered. One branch had died from fire blight, or something much like it, but there was no other dead wood obvious. Larvæ and new sets simply swarmed—on the trunk, branches, twigs and even the leaves—everything was speckled with yellow, moving dots or fixed white ones. No adult *Chilocorus* was seen, but there were a number of pupæ and some few larvæ. It was easy to overlook larvæ had there been any more present, but in any case the scale had much the best of it up to that point. July 24th, a new top was put on the cage to replace unsafe wire netting. The tree was in horrible condition—fairly incrusted with scale and even the leaves coated. Larval, pupal and adult *Chilocorus* were present in some numbers, and, of the active stages, all were, evidently, scale-feeding. A month later the tree looked worse and the scale more numerous, but there were more beetles than ever before, and the question of sending out a few colonies began to be worthy of consideration. September 20th, two colonies were taken out, and before October 6th I practically cut the whole thing to pieces to obtain colonies and

food for them. The cage was removed, and what remained of the tree was cut down about the middle of October. A number of shoots were carried into the laboratory and closely examined, and I was surprised to find how large a proportion of the scales on the trunk and branches had been torn out by the beetles.

October 27th, set a nice, clean Mountain Rose peach, five feet to tip of main shoot and sturdy in proportion.

TREE 33—*Dwarf Duchesse.* Was sprayed twice with Calcothion in March. On the 24th blossom buds were starting all over the tree, and the promise was for a full bloom. April 17th, leaf buds were just opening out, blossom buds were partly opened and showed frost effects. A week later was in full bloom, and from that point developmen of foliage, etc., was normal. Made a full set of fruit, of which just a dozen developed normally until September 16th, when all save one or two were blown off. In size, the pears were average; in shape, normal, and in appearance, good; not more than half a dozen scales on any of them, and some entirely clean. The foliage held on until late in October, and the tree, on the whole, looked well, except that there had been no sufficient replacement of the fruit spurs that went out of service this season. No scale breeding was noted until June, when a few specimens were seen on the fruit and on the new wood. By the end of August there was even less than in July, and only a little was added in September. October 20th, there was considerable on the trunks and larger branches, though much of it seemed dead, and very little was on the new growth.

It is worthy of note in this connection that a half-grown scale in the black stage may remain on a slow-growing surface for months after the insect underneath it is dead. Slightly-infested stock, fumigated in late fall and reset in the nursery, would be found, twelve months later, in exactly the same condition, with the same identical scales in the same stage of growth.

TREE 34—*Lawrence Pear.* Received the two sprayings with Calcothion in March and started growth during the last days of that month. April 17th, was coming out in good shape and had one blossom-cluster in full bloom. It grew fairly well for a time, but set no fruit, and reached its limit before the end of July. In late October the foliage dropped and the tree was ready for winter in fairly good shape. Plant lice appeared in July and curled up some of the tips, while pear slugs scraped some of the leaves so that the tree pre-

sented rather a disreputable appearance during late summer, and this was not improved by the September storm.

The scale situation is about as it was in spring—quite a bit at the base of the branchings, very little, indeed, on the new growth. At no time during the season did I find larvæ. The scurf at the branchings covers more dead than living insects.

TREE 35—*Japanese Walnut.* This tree was very imperfectly sprayed with Calcothion, only the trunk and lower part of the larger branches being treated. Leaf-buds were opening April 11th, and by the end of the month blossom-clusters developed. Only a few nuts actually set, and the harvest consisted of exactly one specimen. A good growth was made and the foliage was in fine shape until the September storm, which battered it sadly. October 20th, everything was dry and brown, ready to come off at the least provocation.

Scale was on the tree all season and always in the same condition —*i. e.,* half-grown and black. October 20th there were no signs of recent sets, no full-grown females and no indications that there had been any breeding whatever. This tree has now been exposed to scale infestation since the fall of 1898, and at no time has there been enough of it to make treatment necessary or even desirable. In the course of inspection work I have seen many of these trees of considerable size, and they are quite susceptible to scale infestation up to a certain point. I never saw any very bad trees, and I never saw any that seemed to have breeding females in any number. The larger the trees the fewer the scales appeared to be in number, and I have about concluded that while this tree is by no means exempt from attack, it is quite resistant and needs no very close watching.

TREE 36—*Apple.* Variety unknown. This is one of the caged trees, and was not treated in any way during the winter. Throughout March and April specimens of the *Chilocorus* could be seen feeding on the scaly trunk and branches, six being the greatest number counted at any one time. During April the cage was completely recovered with wire netting. Not until after the middle of May did the tree make any start at all, and at that time a curious condition was noted. A brood of the common apple plant louse had hatched and become full-grown before there was even the sign of a growth —many of them had been parasitized, and most of the remainder died off from a disease that turned them black—so we had opening leaf-buds from twigs densely set with dead plant lice. June 22d, the tree was in full foliage, was badly infested by the common apple

louse, had great bunches of woolly lice on twigs and branches, was becoming black from the smut fungus, had a full set of young scales and a mass of larvæ that were already spreading over the leaves, as well as the twigs. Larvæ, pupæ and adults of *Chilocorus similis* were now present in some numbers, but they seemed to make no impression upon the scale host. July 24th, the tree was dying; scale-coated from top to bottom, woolly lice plentiful and the common apple louse yet present in some numbers. Adult *Chilocorus* were noted at this time, but no larvæ. August 24th, the tree looked black from the soot fungus and there were more *Chilocorus* larvæ than ever before. There were also some pupæ and a few adults. From this brood I began sending out colonies in early September, and the tree was practically cut to pieces to make food-supply. Here I noted more particularly how large a percentage of the beetle larvæ and pupæ had been parasitized. A number of pupæ were on the sides of the cage, so this was left with open doors that the adults, as they matured, might work their way out. Practically nothing remained October 3d; the cage was taken down and the stump dug out.

October 27th, set a nice, clean, Redmond's Favorite peach, five-foot trunk and stout in proportion.

TREE 37—*Spaulding Plum.* Received two coatings of Calcothion in March and began to open its blossoms before the end of that month. By the middle of April it was in full bloom and one mass of white. By the end of the month was leafing out fully, the bloom was over and fruit had set. May 19th, everything was getting along nicely, some fruits were already half-grown and there were as many as the tree ought to bear, but some of these already showed the curculio crescents. A month later, though some fruit had dropped, there was yet a plenty left, a goodly proportion free from curculio infestation. But about this time the fruit rot began to come in, and before the end of July every last fruit was gone—not a single sound plum matured. For some time I kept the fruits picked off as fast as I noticed the decay, but as this did not in the least check it I cut the tree out altogether.

Up to July 24th there had been no scale development on the tree, and none was noticed on the fruit, which usually attracts the larvæ.

October 28th, I set an imported Duchesse pear which had been grown for trellising, had remained one year in the New Jersey nursery and was somewhat infested with scale. It was not a good tree, hardly

dormant and had the gnarled appearance of a specimen too often transplanted and too long in the nursery row.

TREE 38—*Baldwin Apple.* Was twice sprayed with Calcothion in March. It made no start until the middle of April, and was not in full foliage until early in May. It grew until late in July, and looked well. The storm of September 16th battered it somewhat and loosened it seriously, so that it was necessary to straighten and pack the soil around the trunk. October 20th, was yet in full foliage, had made a satisfactory growth and was developing some fruit spurs. There were a few blossom clusters on the tree, and half a dozen fruits developed until they were blown off, in September. Plant lice, with the accompaniment of soot fungus, became obvious in June; but a month later this was pretty well outgrown—only some black patches recalling the attack. Leaf-hoppers also became obvious in June, and continued throughout the season, spotting the foliage so as to give it a yellowish tint long before October.

This tree was marked as practically free from scale on the trunk and larger branches, "but quite a bit on some of the outer shoots," in October, 1902. Up to July 24th, 1903, the condition remained good. The old wood was cleaning up, last year's growth showed numerous white spots, where scales had dropped off, and on the new shoots only a few specimens were noted. But there had been some breeding, and a month later there was a more general, though slight, infestation—none of the fruits showing even a single scale. September 20th, the scattering was more general, but a brood was under way, which, late in October, had set abundantly at the base of this year's growth, and especially at the base of the fruit spurs. The old wood remains clean, and the new growth, while specimens extend well out toward the tip, does not show any injury; but the fruit spurs do appear thin and dwarfed, and as though they had been drained of vitality by the specimens that set on them and at their base. The remarkable feature of this record is the almost practical freedom of the tree until so late in summer, and the rush of infestation after mid-September, which changed a practically safe tree into a badly-infested one that demands winter treatment.

TREE 39—*Fallowater Apple.* Received two applications of Calcothion in March, and needed them badly. A start was made about the middle of April, and by the beginning of May there was a fair covering of leaves on that wood which still had life, but almost half the tree was dead. June 22d, almost every living tip was curled

up by plant lice, and there were woolly lice in masses at several points. But it had one fruit, and I left the tree to see whether it would mature at least that sample. July 24th, it began to die from the top. The leaves were purplish-black, instead of green, as the result of plant lice attack and soot fungus. Leaf-hoppers were plentiful, and woolly lice only less so. August 24th, the lone apple dropped, unripe, and on the 26th the tree was cut out.

June 22d, it was noted that there was a little new scale, and that there had been a scant breeding. A month later matters were certainly no worse, and the tendency was rather to a cleaning up than otherwise. August 24th, while there was more scale on the new wood, and there had been a well-developed second brood, this could not be charged with the condition on the tree.

This was a scrub from the beginning, and was expetced to die long since. It was one of those specimens that seem to invite insect attack from all sides, and was also made the subject of several experiments, that might have been expected to kill it; yet it survived them all, and I have no doubt that, had I cut it back severely and given a chance for a new start, the tree would have made another effort.

October 28th, set an imported apple, grown for trellising, which had been in a New Jersey nursery one year and had become somewhat scaly. It is not a vigorous-looking tree, but seems dwarfed.

Tree 40—*Lincoln Coreless Pear.* Was sprayed March 3d with the concentrated lime, salt and sulphur wash. The application was inadvertently made, as it had been intended to leave this tree altogether untreated, to test its resisting powers. Growth started about the middle of April, and the usual long, rank shoots were made by July 24th, when they stopped. The foliage was good throughout the season, and still held on well late in October. At that time the bark of the new shoots was unusually rough and scurfy, as if from some caustic application that had scarred the surface. Fruit spurs were making in small quantity, but nothing like what a tree of its age should have. A few tips died early in the year, as the result of some trouble that blackened the pith, and some leaves were scraped by slugs; otherwise no adverse conditions developed.

The scale situation was a repetition of the previous records, apparently uninfluenced by the winter treatment. There was a gradual increase until August 24th, when new shoots and even the leaves were set with young and half-grown examples, and a following decrease, which, in late October, left only a few live specimens.

TREE 41—*Greensborough Peach.* Received two applications of Calcothion in March and made a start in growth about the end of that month. There was a fine show of large, open flowers April 15th and some fruit set, but none of it developed. May 19th, was in full, vigorous growth, which continued until the beginning of August. When tree 37 was cut out it was allowed to fall, so as to hit No. 41, break the top and most of the branches on one side and so make a lopsided plant. This was so bad that I decided to cut it out, and did so on September 20th.

No scales appeared on the new wood until toward the end of July, and these evidently came on from either 39 or 40. By August 24th there seemed to be about one scale at the base of each leaf, and these were full-grown and ready to reproduce. Had the tree been allowed to remain, I believe there would have been a very decent coating of scale on it in October.

October 27th, set a clean Elberta peach, six-foot trunk height, and stout in proportion.

TREE 42—*Elberta Peach.* A rather small tree, clean when received, was set April 17th and cut back to a three-foot stick. Had not made a fair start until the middle of May and ceased growth by the middle of July. October 20th, it did not look very flourishing and could hardly be considered a satisfactory representative of the variety. No scales were seen until July 24th, when three specimens were found on the trunk. A month later these had disappeared, but on the new growth there were single scales at the bases of the leaves. October 20th, almost every leaf had at least one full-grown scale at its base, but there was no appearance of breeding at that time.

The Elberta tree, for which the above is a substitute, began to die late in the fall of 1902, after making the excellent record given in the report for that year. As the season advanced the tips began to shrivel and die, the larger shoots followed, and as the bark was tested further down on the branches it was obvious that the tree would never start again, so it was cut down and the stump was taken out.

TREE 43—*Early Richmond Cherry.* Received the two applications of Calcothion in regular course in early March and began growth at the end of that month. Was in bloom during the last days of April, and set fruit, which developed until it was sufficiently attractive to the robins, then it disappeared. Growth had ceased by the end of June, and soon after some of the foliage was scraped by slugs, but not enough to cause injury or to be even disfiguring. A few scales

came on from time to time during the season, but failed to maintain themselves, and, October 20th, when the foliage was about ready to drop, only a few half-grown examples could be seen. Orchard experience is the same, and this variety of cherry may be said, in a general way, to be proof against this pernicious scale.

TREE 44—*Elberta Peach.* This tree received the two applications of Calcothion and was in very bad condition—so bad that I expected it would have to be taken out. Not until well along in April did the buds begin to open, and on the 17th of that month it was in full bloom. It was in leaf and out of bloom May 1st, with a good fruit set. June 22d, most of the fruit had dropped, yet there was enough remaining. The tips and some of the branches have begun to die and some are dead, but the new shoots in the center of the tree looked well enough. August 24th, about a basket of fruit remained, fully colored, but utterly unripe; some of it starting to rot. Branches continued to die and the tips of nearly all were already gone. The fruit began splitting late in August, and was taken off, September 22d, yet unripe, to be fed to the children's rabbits. September 6th, cut back all the branches to sound wood—practically dehorned the tree. October 20th, what remained was in excellent condition—the shoots in the center of the tree looked well, and the set of fruit buds was heavy.

Not much live scale was found in the tree June 22d, and up to that time there had been no breeding. A very little was seen on the new wood July 24th, and on the examination made October 20th the new growth had only a very small set. There was quite a coating on the branches from the main trunk, but much of this is old, covering dead and collapsed examples.

The death of No. 42 and the partial dying of No. 44 can scarcely be explained by charging it to scale attack, though both trees were pretty well infested. I have seen trees very much worse that have lived through the winter and entirely recovered under proper treatment. Nor was there anything in the applications made that should have caused such injury. Certainly, at the date of this record, there is not enough infestation to endanger the life of the tree.

TREE 45—No tree under that number at present.

TREE 46—*Mountain Rose Peach.* Received two applications of Calcothian in March, and began growth by the end of that month. Was in full bloom April 17th and coming into leaf. Was in full foliage May 19th, and had made a good set of fruit. Growth con-

tinued rank and good until well along in July, and the fruit developed normally. It began to ripen early in August, and by the 24th I had picked two and one-half baskets of as fine specimens of the variety as I ever saw. September 16th, the storm loosened the tree and tilted it badly, but it was straightened and packed into place next day. October 20th, foliage had begun to drop, and most of it was ready to go at a touch. The growth had been satisfactory, and the set of fruit buds was all that could be desired. As to scale, very little of it was seen on the new wood until late in August, and there certainly had not been anything like a large brood anywhere on the tree. At the October examination practically nothing was found on the old bark of the trunk and main branches, and so little on the new wood that treatment seemed hardly necessary, except as it would guard against the development of a heavy brood late in the summer of 1904.

Tree 47—*Greensborough Peach.* Received two applications of Calcothion in March, and began its start late that month. Was in full bloom April 17th, and set a few fruits—none of which matured. Came into full foliage early in May, and continued to grow until the beginning of August, making good, healthy shoots. October 20th, it was a nice, symmetrical tree, and had made a good set of fruit buds. There was a very general infestation on this tree late in 1902, but no larvæ had developed June 22d, and no brood had appeared July 24th, when no scales could be found on the new growth. August 24th, infestation was first noted, and September 20th it was still slight. October 20th, there was scale all over the tree, about as it was in the fall of 1902, and probably most of it from the outside.

Tree 48—*Black Tartarian Cherry.* One application of Calcothion was given in March, though the tree was not scaly. A start was made by March 24th, and by the middle of April was in full bloom. Was hit to the extent of fully one-third by the frosts of early April. Late in that month was in full leaf, and had set a light crop of fruit. The latter developed normally until it began to color, and then the robins took every last specimen. There was rather a short, though healthy, growth during the season, and on October 20th the foliage was about ready to drop. A heavy set of fruit buds has been made. No scales were observed until October, and the infestation then consisted of a few half-grown examples, widely separated and, perhaps, not even alive.

There is a marked contrast between this tree and No. 3, which is

of the same variety and of the same age. Up to the fall of 1901 the two were practically alike, but in 1902, while No. 3 grew normally, No. 48, which had been transplanted, did nothing at all, except maintain life. In 1903, while there was some growth, it was of a sort of tentative nature, and rather in the direction of forming fruit than an increase of size. It is a repetition of my experience with the old apple trees which were overgrown when I received them and had started to bloom. The check from transplanting was never overcome, and for three years no fruit spurs were formed.

The lessons of the season have been interesting. The concentrated sulphide salts proved absolutely useless; but this might not have been the case had it not rained so heavily so soon afterward. Yet as this is something always to be expected in our climate, any readily-soluble substance that does not act very promptly must always be more or less uncertain in its results.

The concentrated lime and sulphur mixtures, if they are to be available at all, must be used very soon after they are prepared, for there is a crystallization that begins as soon as the mixture settles, and as this progresses the chemical combinations change, so that to spray the wash at all the effective particles must be strained out.

That Calcothion retained its effectiveness to as great an extent as it did speaks well for its stability. There is no doubt but that it killed most of the scales on the trees on which it was applied, and in every instance materially retarded the date at which reproduction began. This can be easily verified by the specific records given and comparing with the untreated trees under the cages. Had it been a fresh mixture, applied when and as it was, I believe it would have given as nearly a perfect result as can be reasonably expected from any mixture. The only really very bad trees now in the orchard are those which were not treated with this material.

A further lesson is that, on trees especially susceptible, the scale may develop with enormous rapidity, late in the season, from an apparently insignificant start. Of course, this is not really new, but it is explanatory of statements sometimes made by fruit growers that they could not see any scale at all in the spring, and yet found their trees coated in the fall.

BIRDS AS INSECT DESTROYERS.

There is considerable misapprehension as to the actual relation of birds to insects, and much difference of opinion as to whether certain birds are really beneficial to the agriculturist or horticulturist. There is, on the one hand, the enthusiastic lover of birds, who admires their song, their plumage and their attractive appearance in the garden, park or forest, and, on the other, the horticulturist, who looks, primarily, to the influence they may have on his crops, and whose pleasure in their song and appearance is marred by the discovery that his fruits and vegetables have been eaten or made unsalable by them. It is easy for one who has nothing at stake to become enthusiastic about the music of the bird choir and to go into ecstasties over the beauty of their plumage. He does not consider that the enjoyment that he expresses, and perhaps experiences, is paid for in hard dollars and cents by the horticulturist, who seems, in some strange manner, to have escaped recognition almost completely as a factor in this bird problem.

During the two or three years last past complaints of bird injury have been steadily on the increase at the meetings of the horticultural society and among fruit growers generally. The summer of 1903 has been a little worse than any other; peas, small fruits of all kinds and cherries suffering most. Blackbirds and robins seem to be the chief offenders, and their depredations are not confined to the garden—they invade the field and orchard as well. Their pickings are not merely the occasional fruit—wormy, according to tradition—but entire trees are stripped, and the nicest fruits go first. On many cherry trees not a fruit was obtained by the owner, and some orchards of smaller trees were completely cleaned out.

A well-written paper in the *Rural New Yorker*, for August 8th, 1903, page 566, puts the horticulturist's point of view very forcibly—"As the earliest strawberries paled and flushed to ripeness the robins and catbirds descended in force, selecting, as usual, the best fruits first, but later became so numerous as seriously to reduce all marketable sizes. Close covering was needed to save fair examples of certain new trial varieties. Juneberries and early cherries came next. There was a splendid crop of the former of both tree and bush kinds. The cherries were comparatively scarce, but just as acceptable to the birds. Not a ripe fruit of either species was secured, except where bagged or

netted for seed-saving. Currants and gooseberries followed as a side issue, the destruction of the red varieties being almost complete before sufficiently ripened for use. * * * This season there was only a brief intermission as the blackcap and early red raspberries colored up. The usual toll of choice fruits taken from these varieties was not grudged, as good pickings could be had by getting out early in the morning. Before the crop was gathered, however, the birds came back, bringing their families of fledglings, together with a great concourse of relatives and friends, and made short work of the remaining raspberries, a fine lot of dewberries, and all the blackberries and wineberries to date. Not a berry is allowed to get to the edible stage from a human standpoint, but is promptly snatched off. Where pickings of fifteen to twenty-five quarts should be had daily, not a good ripe fruit can be found.

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"Grapes and apples have not yet reached a stage inviting to the birds, but we are concerned lest they may be attacked in due course. There are practically no peaches, pears or plums this year to succeed the berries. The only fruits so far ignored by the feathered pirates are mulberries, strawberry-raspberries and the Elæagnus fruits, all of which were in good quantity. The failure of the usual crop of roadside cherries and the local clearing up of waste lands and bramble thickets may account in part for the unusual destructiveness of the birds this particular season; but each successive year brings a noticeable increase in the birds infesting fruit gardens, until we may conservatively say that robins and catbirds not only form a greater menace to horticulture than the European sparrow, but are likely to cause more loss to the grower in the long run than the vagaries of our climate, insect pests and fungus diseases combined, as our present experience shows that they are capable of appropriating the entire crop before full maturity, instead of a reasonable fraction, as is so often urged."

The owners of orchards and gardens who have lost hundreds of dollars naturally feel bitter toward the birds, and when they are met by the assertions of those who have nothing to lose, that the birds are of enormous benefit in keeping down injurious insects, they have the right to demand proof. That many birds eat insects is, of course, true, and a goodly number never eat much of anything else. The latter never can become injurious to the farmer, though they may be of little direct benefit. The mere fact that a bird eats insects does

not thereby make it directly useful, because, as a matter of fact, only a very small percentage of the insect species are really injurious to cultivated crops. Unless, therefore, a bird actually feeds upon an injurious species it is of no practical benefit; indeed, if such a one adds to its normal insect diet even one of the farmer's fruits, it is injurious by just so much.

As an example: a grower of potatoes finds his worst insect foe in the potato beetle, adult and larva; any bird that eats of these insects is directly beneficial, and, should such a bird also exact a toll from the same or even another crop product, the question would be, does not the benefit overbalance the harm. On the other hand, there might be hundreds of insectivorous birds which did not touch potato beetles nor any other insect that injured his crop in his field, and the whole gathering could, at the best, be considered as harmless.

So, in an orchard infested by tent caterpillars or web-worms, one hundred robins would not equal one cuckoo, and every robin could cause more direct injury than all the insects that it eats in the entire course of its life.

Sentiment aside, the question is, does a bird eat enough insects directly injurious to the orchardist to pay for the fruit that it eats? If it does, it is injurious, and the fruit grower should be entitled to protect himself against it. In my own garden I have both cherries and strawberries, and the robins got every cherry and mutilated most of the strawberries. In return they ate a few worms, which were beneficial rather than otherwise, but not a caterpillar, slug or curculio, which were distinctly harmful; in fact, when there was no more fruit to their liking, I saw little of them. My experience was, on a small scale, the experience of that of many fruit growers on a large scale.

No one can deprecate more than the writer the indiscriminate slaughter of birds or other animals. Life should never be taken without good reason, and the wanton killing for mere "sport" has no justification in any case. So, the killing merely to obtain material for personal adornment is a remnant of savagery to be restricted to the narrowest limits. But man has assumed that he is the center of the universe and that every life that he can conquer is meant to be for his own personal use. Therefore we kill such animals as minister to our comfort by their flesh or their hide without remorse or protest, and we kill equally all those that become dangerous to the lives of ourselves or our domestic animals, but, apparently, we have not

yet come to the point where the product of the farmer or the horticulturist is considered worthy of protection as against animal life, even if it is not of the least practical benefit to him or anyone else.

We learn of certain birds that they are great feeders on grasshoppers and the like, and their depredations are excused by figuring out the supposed benefit as against the value of the destroyed fruit, but it is not stated in these cases that grasshoppers do not bother fruit trees, nor is it mentioned that a flock of young turkeys would do even better work without exacting the fruit toll.

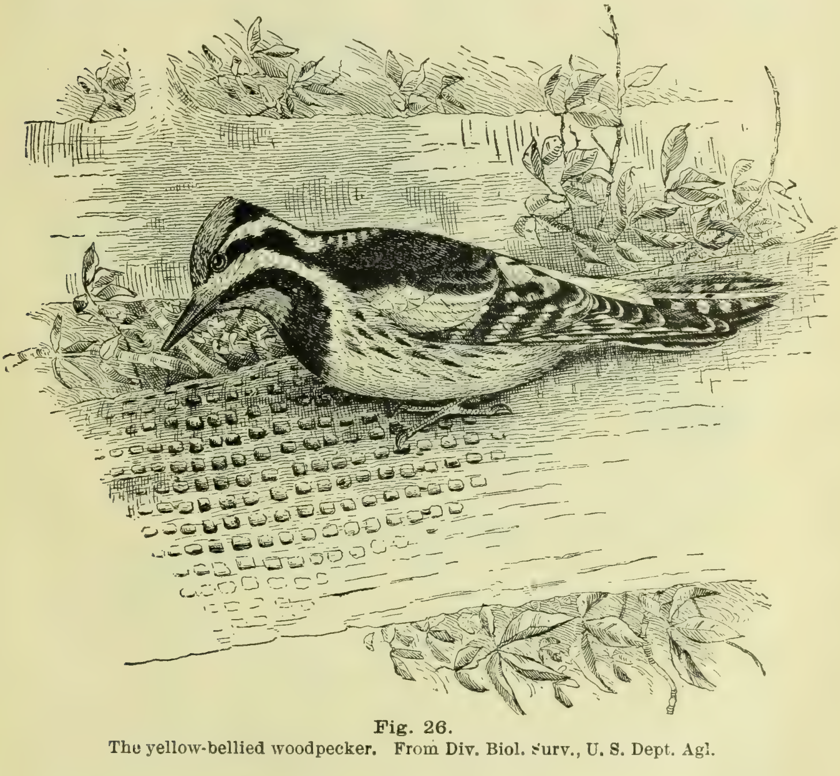

Fig. 26.
The yellow-bellied woodpecker. From Div. Biol. Surv., U. S. Dept. Agl.

The Division of Biological Survey of the United States Department of Agriculture has made, and is yet making, a careful study of this bird question, hundreds of stomachs having been already examined to determine the food of the species investigated at different seasons of the year and in different sections of the country. So far as the results of these studies have been published, they form the

basis of the statements as to food habits made in this paper. Additional information has been obtaind from the studies of Professor S. A. Forbes, of Illinois, and other available sources, notably the book on "Birds in Their Relations to Man," prepared by Drs. Clarence M. Weed and Ned Dearborn. There is no pretense to any completeness or originality of treatment here, and only some of those groups of birds that are sufficiently numerous to attract attention in New Jersey are regarded. Furthermore, it is the fruit grower or horticulturist that is chiefly considered, though not exclusively.

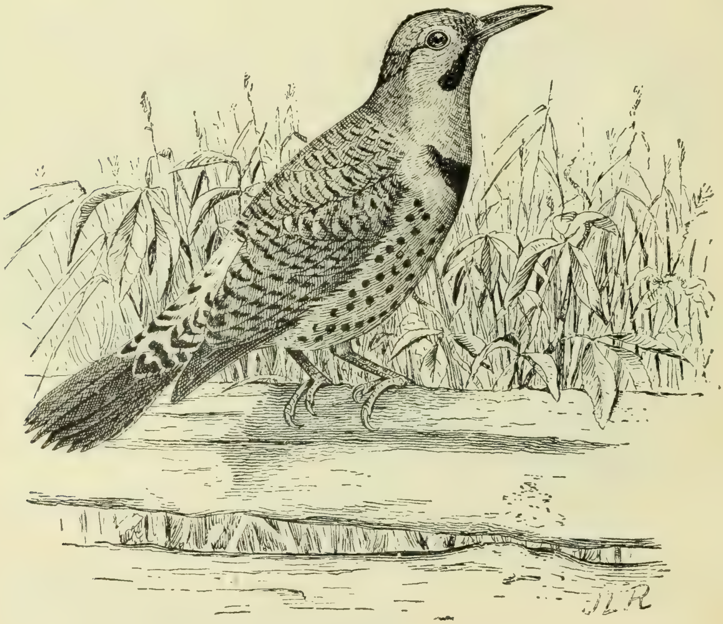

Fig. 27.
The flicker. From Beal, U. S. Dept. Agl.

The hawks and owls are strictly predatory in character. Insects are included in the food of some species, while they form a large part of the bill of fare of the screech-owl and sparrow-hawk. To the horticulturist all these birds are distinctly useful, since, besides insects, they also eat mice and other vermin that injure fruit trees. To the general farmer they are equally useful, aside from the habit that some of the large species have of taking an occasional chicken or other barnyard fowl.

Woodpeckers are, on the whole, beneficial, if we doubtfully exclude the yellow-bellied sap-sucker. The latter species punctures the bark to obtain the sap which fills the holes it makes, and it makes the holes in bands or spirals close together around the trunk. On old apple trees the trunk is sometimes literally pock-marked, but rarely do they show any real injury. In large, open orchards of young trees the birds are seldom seen, and the damage done by them does not offset the good accomplished by the other species. The flicker does not puncture bark to get its food, but picks most of it from or out of the ground; ants forming a large percentage of the insect diet. Such vegetable food as it takes is not usually of much economic importance. The

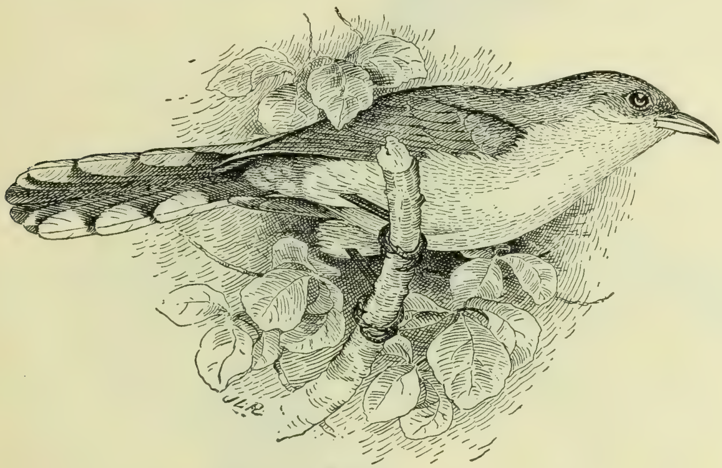

Fig. 28.
The yellow-billed cuckoo. From Beal, U. S. Dept. Agl.

red-headed woodpecker has somewhat similar habits; but between the two they eat about as many useful ground beetles as they do harmful species; so, while they certainly should not be persecuted, there is no particular reason why they should be especially encouraged.

As for those woodpeckers that seek out boring insects under the bark, they are distinctly useful, since, when they find no borers, they pick specimens from beneath bark scales or out of crevices. No well-kept orchard has flat-headed borers in any number, because their presence is always an indication that the tree in which they are found is low in vitality.

The American cuckoos are probably the most useful birds that come into our orchards. They rarely touch fruit of any kind, and they

do eat, by preference, those hairy caterpillars that most birds reject. I have seen nest after nest of tent caterpillars completely cleaned out by these birds, and they fill, in every particular, the requirements to make them of the highest value to the fruit grower.

The fiy-catchers, or pee-wees, are almost as valuable, though their food is more varied, and many harmless and beneficial insects accompany the injurious forms into the ever-ready beak. A little wild fruit is eaten, but there can be no question as to the economic importance of these species.

Fig. 29.
The kingbird. From Beal, U. S. Dept. Agl.

The kingbird belongs here, and is almost exclusively an insect feeder. It is a well-known species, and should be encouraged everywhere. It does not discriminate much, eating anything that comes in its way; hence it has aroused the enmity of some apiarists, who have seen it devouring their bees. It is said, however, that the bee-eating habit is exceptional, and, at all events, it may be fairly claimed that the good accomplished far outbalances whatever harm is done.

The swallows, also, are to be placed with the distinctly useful

birds, their food consisting almost entirely of insects. They have the advantage of breeding freely near human habitations, and the purple martins nest readily in boxes. Their usefulness is quite generally recognized, and "martin-boxes" are not uncommon, but much less common than they should be.

The nuthatches, titmice or chickadees, creepers and wrens are useful, because the insect food which some of them get in the crevices of rough bark and under bark scales far outweighs the scant vegetable food which is taken.

Warblers and vireos, also, are among the good species, since they eat many species that are directly injurious.

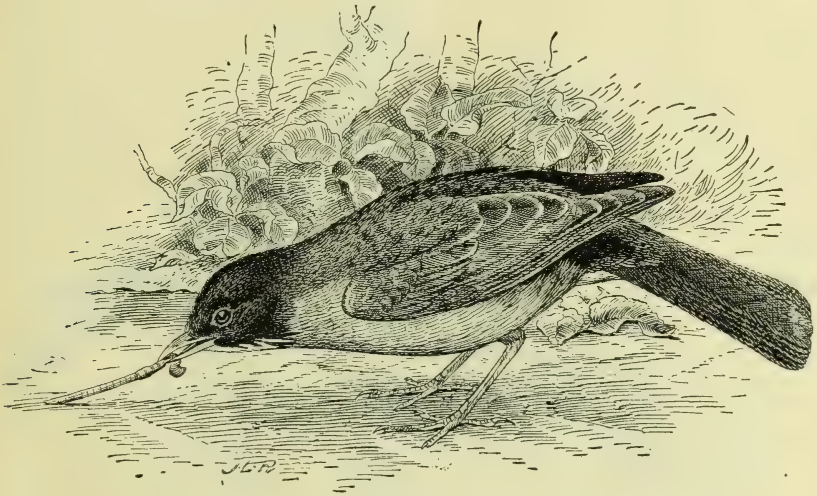

Fig. 30.
The robin. From Beal, U. S. Dept. Agl.

The *status* of the robin seems to be in dispute, chiefly because the factors, so far as New Jersey is concerned, have not all been properly stated. It may be considered that, under conditions as they existed even ten years ago, with robins few in number and wild fruits more abundant, the birds could hardly be considered as injurious, even if not actively beneficial. Under the protection accorded them they have increased in number, have become bolder as they realized their immunity and have devoted themselves to cultivated fruit as the wild land diminished; and the aggravating thing about it all is that when the birds have become full fed here and are in good condition, they migrate to the Southern States, in some of which they are killed

off in great quantities and sold as food for a small fraction of the value of the fruit destroyed by them.

I have carefully studied the available records of the food habits of the robins, and there is not a single species of economic importance eaten by the bird which cannot be easily kept in check by the horticulturists. Chickens, turkeys or guinea hens eat every injurious surface insect that the robin would touch, and do not eat so many of the predatory ground beetles. As to the really troublesome orchard pests, the horticulturist gets absolutely no benefit from these birds. Nowhere have they made spraying unnecessary.

Fig. 31.
The crow blackbird. From Beal, U. S. Dept. Agl.

The blackbirds are in the same class with the robins, and are, indeed, admittedly more harmful than useful where they occur in large numbers. They are not protected in New Jersey, but the game laws are often so unreasonably enforced that many farmers hesitate to thin out even these pilferers for fear of annoyance.

The catbird also is injurious rather than otherwise, though it does eat great quantities of insects; because the injurious species that are eaten could be easily taken care of more cheaply. The thrushes, which have much the same general habits, are not plentiful enough to cause material injury.

Cedar-birds are locally troublesome on small fruits, especially cherries, but are much less complained of, and, on the whole, more than make up for what damage they do.

The English sparrows are a great nuisance, but are less directly harmful to the horticulturist than the species just previously referred to. There is no reason why they should receive any protection, though they do eat a certain amount of insect food. But this condemnation does not apply to the native sparrows and finches, which merit our care and protection.

Fig. 32.
The cedar bird. From Beal, U. S. Dept. Agl.

As to the crow, its economic standing is in dispute. It is hardly to be considered as a valuable bird from the insect-eating standpoint, but it does not injure the orchardist directly to any appreciable extent. Farmers do not as a rule feel very kindly to it.

For the purposes of this essay, the blue jay stands with the crow, but the bluebird must not be confounded with it, because that is essentially a useful species, whose presence should be encouraged.

It would be a mistake, in my opinion, to relax the stringency of the law to an extent that might give even the shadow of an excuse for a general slaughter of birds. Of some of them we can never have too many specimens. There are others, like the robin, the blackbird, and

the cedar-bird that are useful when in moderate numbers, but are the reverse when allowed to become abundant. It is unjust to compel the fruit grower to sit by and allow the result of his labor to be devoured by a bird that yields him nothing in return, and it is adding insult to injury to fine him for destroying nests in his fruit trees, when he knows that the nestlings will fatten on his fruit as soon as they are capable of feeding themselves. There should be a show of reasonableness even in the game laws, and the interests of a bird fattening on our fruits for the market of some of our sister States should not be held to be superior to those of our horticulturists.

In a consultation with Dr. T. S. Palmer, of the Biological Survey of the United States Department of Agriculture, it appeared that similar questions had become acute in other States and had been adjusted by adding to the game laws a paragraph more or less like the following:

Provided, that nothing in this act shall be construed to prevent any resident of the State of New Jersey from killing birds which are found injuring or destroying the grain, fruit, berries, garden or farm products on his premises, but birds so killed shall not be offered for sale, bought, sold or shipped out of the State.

There should be no objection to this from bird-lovers, and the horticulturist should not, at present, demand more.

REPORT ON THE MOSQUITO INVESTIGATION.

REPORT ON THE MOSQUITO INVESTIGATION.

BY JOHN B. SMITH, SC.D.

The study of the problems indicated in Chapter 98 of the Laws of 1902 was intended to extend through two years, but as the money appropriated was not actually made available until the spring of 1903, less than one year has passed, and this is a report of progress merely. The preliminary studies made during the summer of 1902 were reported upon in that year, and they served to indicate the lines upon which the investigations would have to be carried on.

Mr. H. H. Brehme, of Newark, who had secured such excellent results for me last year, was put into the field in March, and has been kept there continuously. His experience in salt-marsh work made it desirable to entrust most of this line of investigation to him, and, first of all, the areas around the large centers of population—Jersey City, Hoboken, Newark, Elizabeth and the smaller adjacent cities—were thoroughly explored. Photographic copies of the original Survey Maps of the State were obtained through the courtesy of Mr. Henry B. Kümmel, the State Geologist, and on these every dangerous area was marked out as soon as it was located. A record of each day's work was kept, and in it is given, not only the general character of the territory surveyed, the character of the infestation found, but also an indication of how the bad condition might be improved.

Mosquito breeding began early, but weather conditions were so unusual that, as compared with 1902, an altogether different order of species appeared on the marshes. After a long drought came frequent heavy rains, and, soon afterward, brood after brood of the brown salt-marsh mosquito, *Culex cantator*. Like the ring-legged form, *Culex sollicitans*, the brown species has also the migrating habit, and, in a few days after they appeared on the marshes, they had extended into and beyond the cities to the edge of the Watchung mountains. As the season advanced the insects increased in number, and developed into a plague of the first rank, extending much farther

inland than in ordinary seasons. An excellent opportunity was thus offered for watching them and for determining their peculiarities in all stages. The migrating habit was fully demonstrated, and the most careful collections failed absolutely to discover any of their larvæ inland, where the adults occurred in countless numbers. The entire area between the edge of the salt marsh and the top of the first range of the Watchung mountains was carefully collected over, and it can be positively stated that only in the salt marsh and along its edge does this species breed. It was further established that the breeding-places are really very limited in extent, and that an expenditure of not over $5,000 would serve to clean up the Newark meadows completely. For Elizabeth the cost would not be as great, while for Jersey City it would be very much less. The city authorities were notified in each case of the results of the surveys on their respective territory.

To determine some of the uncertain points in the life cycle of the marsh mosquitoes two large cages of wire netting were built and placed on the marsh, and the insects were bred from larvæ to maturity and allowed to live and develop as they would. Frequent visits to these cages and the records made cleared up several doubtful questions.

Mr. Brehme's survey was continued to the south as the season advanced, and in the Monmouth Beach area, extending from Sandy Hook to Long Branch and along the Shrewsbury and Navesink rivers he co-operated with Mr. Eugene Winship, Secretary of the Monmouth Beach Improvement Association, in a study of that region—a point that will be again referred to later on.

A preliminary survey was made early in the season of a portion of the Barnegat Bay region, near Beach Haven, where more work was done later.

As the question of mosquitoes is always an important one at the large seaside resorts, nearly three weeks were devoted to a survey of Absecon island, on which Atlantic City is situated, and its surroundings. This included Brigantine Beach, the Ocean City strip and all the intervening marsh area to Pleasantville and Somers Point. So much work of general improvement has been done at Atlantic City, Ventnor, South Atlantic and Longport, that what is left is only a mere fraction of what has been already accomplished. Nevertheless, some bad conditions were discovered, and maps showing all these facts were sent to the mayors of the various municipalities involved.

The Barnegat Bay problem was again taken up by Mr. Brehme late in the season, and the survey was carried on along the mainland and up the various creeks and rivers so far as marsh land extended, from Bay Head to Manahawkin.

Another important work done by Mr. Brehme was along the first ridge of the Watchung mountains to determine the species of mosquitoes that breed in the woodland pools. It was a matter of some importance to know whether the insects that were found there would migrate to the towns and villages not far away. In a general way it was found that they were not migratory, and did not, as a rule, get far away from home.

Mr. John Grossbeck, of Paterson, was also placed into the field early in the season, and was employed for a time to assist in the work with the marsh mosquitoes. The region from the mouth of the Raritan river to New Brunswick was carefully mapped out and a section of the Barnegat Bay strip, from Barnegat City to the Junction, was surveyed.

As the season advanced Mr. Grossbeck was detailed chiefly for inland service and made a very full map of the Hackensack and Passaic Valley regions, in which every dangerous breeding-place was located. The information so gained will prove of the greatest importance whenever practical work is undertaken by the communities interested. In response to a request from the Board of Health at Trenton I assigned him to make a careful survey of that city and its environs, to locate places where the *Anopheles* or malaria-carrying mosquitoes might breed. This survey was extended southward to Bordentown, and the information obtained was placed in the hands of the Board of Health. Similar surveys were made at the request of other municipalities, and maps are in hand of breeding-places about Lake Hopatcong, Hackensack, Plainfield, Metuchen, etc. In most of these cases the health officer or some other local representative co-operated in the work and received the information secured.

Beside this, Mr. Grossbeck rendered services in the Laboratory in working up the immense amount of material accumulated during the season.

Beginning in June, Mr. Henry L. Viereck, of Philadelphia, was employed for a time in the vicinity of Camden, to determine mosquito conditions there, and was then located at Cape May until October 1st. Conditions at this place were peculiarly favorable to a study of the life habits of the marsh mosquitoes, and the complete history of

the most important of them was worked out. An important point investigated was the influence of the internal parasitic worm, *Agamomermis culicis*. The curious fact developed that at one period fully 80 per cent. of the examined mosquitoes were wormy and that at least one of the broods was materially reduced by the parasites. No less than seven broods were watched throughout their development, and, in addition, eggs were secured from specimens in captivity for the purpose of testing their vitality. Mr. Viereck was located almost at the edge of a pool roughly 20 x 100 feet, containing an area of somewhat less than 2,000 feet, and in this mosquitoes bred throughout the summer. At one time he tested the pond by dipping from various parts and counted the larvæ found in the dipper, as a surface of known area. Averaging these dips and calculating for the entire pond area, indicated a population of 10,600,000 specimens of mosquito wrigglers. Counting only five instead of the seven broods, we have the astounding number of 53,000,000 mosquitoes from one pool, not exceeding the area of an ordinary city lot.

It is a common belief that the inland swamp areas on the Cape May peninsula are prolific mosquito breeders, but this proves to be a mistake. Mr. Viereck covered the shore territory roughly to Ocean City and thoroughly to Seven-mile Beach. Inland, all the low area from Skellinger's landing diagonally across to Sea Isle Junction was closely collected over. It is a most important fact that, while throughout this area *sollicitans* was the only troublesome mosquito, not a larva was found away from the salt marsh region. The practical bearing of this is that as Cape May has ocean or bay to the east, south and west, and high land along the Delaware Bay shore, it can get no marsh mosquitoes from outside its own territory, except such as may come from Two-mile beach. It is practically the only shore resort in New Jersey where local effort will produce freedom, and it will not require an expenditure of over $2,000 to do the entire work. With its unequaled shore and its sea breezes from almost every point of the compass, it needs only the elimination of the mosquito to make it an ideal resort.

Developing with the salt-marsh mosquito, Mr. Viereck found the larva of *Anopheles crucians*, which is practically absent elsewhere in the State, and this was also bred to maturity in some numbers.

Especial attention was paid in this study to the fish and other water animals that occurred with the mosquito larvæ, and, so far as possible, their influence upon the latter was determined.

For a period of two months during midsummer Mr. E. Brehme, of Newark, was engaged to assist in looking after the Newark marsh experiments and in a survey of the area at the foot of the Palisades, from their southern point, to Fort Lee.

Messrs. Charles Wagner, of Elizabeth, and John Mellor, of New York City, were engaged, from the middle of June to the middle of September, as engineers, that I might secure accurate data as to the probable cost of such work as was necessary to improve marsh lands so as to make them safe from the mosquito standpoint.

The first problem assigned to them was the drainage of the mosquito-breeding marsh area near the mouth of the Raritan river. From this area the Raritan valley is flooded by countless millions of the insects, extending to New Brunswick in clouds, and to Bound Brook in considerable numbers. A population of over 50,000 is directly affected at all times, and a considerably larger number is reached in seasons like that of 1903.

The result of this work appears in two maps, on which is outlined a complete scheme of drainage, showing not only the general course, but the number and length of the ditches required. Briefly stated, it needs 357,710 feet of ditching, two feet deep, most of which need not be over six inches wide. Machine ditching, of the width and depth mentioned, costs 1 cent per running foot, and this would give $3,580 as the amount required to do the work; but as some of the ditches are very short and some are on land not suitable for machine ditching, an outside estimate of $5,000 is made to accomplish the desired end—less than 10 cents for each inhabitant!

From the valley of the Raritan, Messrs. Wagner and Mellor were sent to Beach Haven, where, as the community was ready to take hold, ditches were not only surveyed, but actually staked out, and part of the work was done under the supervision of Mr. Mellor.

Mr. Wagner was, during Mr. Mellor's engagement at Beach Haven, assigned to Seaside Park as headquarters, for a survey that was carried south as far as Barnegat inlet and north to Chadwicks. The problem on this strip is somewhat different from that at most other points along the coast, because it is almost all sand and only a thin coating of vegetable matter is on the surface. As a result, ditches will not stand, and filling remains as the only resort. Fortunately there are plenty of sand hills that can be readily used for that purpose along most of the strip. Where there are none, sand can be obtained by dredging from the bay, as is done at Atlantic City and

at other points along the coast. There seems to be no good reason why this should not become one of the most attractive stretches along the coast.

With the beginning of September the survey of the Cape May territory was taken in hand, and, in a general way, the conclusions based on the work done has been already stated. The marsh extending half a mile from Cape May city to the light-house is the worst of the breeding area, and most of the water there can be drained off by a tide-gate and a few simple ditches. There is scarcely another place known to me where so small an expenditure of money will produce so great a result. It was for this reason that I spent so much time there, that I might be able to induce the local governing bodies to take the matter in hand. A meeting of some of the members of Councils, of the Board of Health and of some other representative citizens was called in early October to consider the subject, and there is a fair prospect that the needed improvements will be made. The work already done by the Cape May Realty Company on their territory along Poverty Beach has been effective in very materially reducing the mosquito pest at Sewell's Point.

Mr. William P. Seal, of Delair, continued his fish experiments, and collected a series of species along the coast at different points to determine the commoner types. His general conclusion is that almost any fish will eat mosquito larvæ when it can get them, but that only Culex larvæ are likely to be taken by any save top-feeders. Tadoples were also experimented with, but both those of the toad and of the frog are useless, except that they may at times get some very young larvæ by accident.

Mr. Seal makes a very good suggestion for dealing with marsh pools of some extent, which, at times, dry up, and, when refilled by rain or tide, are bad breeding-places. In the lowest point in such areas a barrel could be sunk, so that its top would be nearly level with the bottom. When the pool is filled it could be stocked with the common *Fundulus*, or "Killies," which occur in every tide-ditch and pool, and these would clear out any larvæ that might develop. When the pool area lessens by evaporation, or becomes entirely dry, so that mosquitoes can lay their eggs on the surface, the fish would find refuge in the barrel, which would never dry up entirely. When the area again filled, and larvæ began to develop, the fish would be on hand to take care of them. This would be a cheap way to deal

with the area mentioned on page 648, where the 50,000,000 mosquitoes developed.

The only fish that is able to deal with the *Anopheles* or malarial species is a top minnow belonging to the genus Gambusia, which is not a native of New Jersey, but occurs in great numbers along the shores of Chesapeake bay. Mr. Seal made several trips to different points on the New Jersey coast to ascertain whether the species might possibly come up during the late summer, but he did not find it in any case. Yet it is not improbable that this little fish would live in some of our inland waters, and the attempt will be made to introduce it. It is certain that it would live throughout the summer, and it may be possible to get a supply that will keep ornamental ponds clean during the danger season at least.

Besides making these observations on and experiments with fish, etc., Mr. Seal made collections of larvæ and aquatic insects, some of which were of great interest. He also located rather carefully the mosquito-breeding areas from his establishment in Delair to and about Riverton.

An important investigation was made by Mr. Horatio N. Parker, meant to determine more accurately the character of the food of the mosquito larvæ. Specimens were sent to him at intervals throughout the summer to be examined as to stomach contents from different sections of the State, and a number of species were studied in this way. Some of the information obtained is of decided interest and economic importance.

Special collections were made for me during the summer at Elizabeth by Mr. Otto Buchholz, to determine the species which were most abundant and annoying indoors and out.

Another series of collections was made by Mr. Harold Marsh in the valley of the upper Passaic, where, ordinarily, mosquitoes are not abundant enough to be troublesome.

During the very early days of the season some extremely interesting material was collected and sent in by Mr. J. Turner Brakeley, from Lahaway, in the pines, near Prospertown. It was positively determined that at least one species of mosquito, *Culex melanurus,* goes through the winter in the larval stage and lives in the spring water holes in Sphagnum swamps. It was further found that the eggs of *Culex canadensis* were in the mud of shallow woodland pools, and that the larvæ hatched as early as February, before even the pools were ice-free. An entirely new species of *Culex* was found a little

later in the season, and perhaps most important of all, a good series of accurate observations as to the arrival of the salt-marsh species at this point, about twenty miles from shore, was obtained.

An interesting instance of the way in which perfectly independent observations may complete each other is afforded by combining records made by Dr. Julius Nelson, Biologist of the Station, with those made by Mr. Brakeley. Dr. Nelson, while carrying on his oyster experiments on the marshes near Tuckerton, noted the general mosquito conditions and found them quite free from adults and larvæ until July 12th. On or about that day an extra high tide came over it, and on the 13th minute wrigglers were in every water-filled hole. Cold, wet weather retarded development, but on the 21st, males were out in clouds and everything was in the pupal stage. On the morning of the 22d the females were out, but would not bite. On the evening of the 23d it was warm, with only a slight breeze, and the doctor was brought from his hut by a peculiar humming noise which seemed to fill the air. He located its source at last between sixteen and twenty feet high above the marsh, where regular clouds of mosquitoes were hovering in their marriage flight. On the 24th few males were seen, but the females were in droves and as bloodthirsty as butchers. Then came cold west and north winds that kept the insects low down among the grass. On the 28th the wind veered to the south and continued all that night and all day on the 29th. On the morning of the 29th the number of mosquitoes on the marsh had diminished materially, and this was yet more decidedly marked on the morning of the 30th, when they were quite bearable. But in the woods where on the 20th there had been few mosquitoes they were worse on the 31st, when the Doctor came out to Tuckerton, than they were on the marsh itself.

Just after receiving this account from Dr. Nelson, I received a note from Mr. Brakeley, giving in great detail a record of the arrival of *Culex sollicitans* in the pines during the nights of July 28th and 29th, increasing during the successive nights to August 1st, when they were distributed everywhere in great numbers. Previously there had been practically none of this species, and the observed departure on the 28th and 29th from the marshes and the arrival in great swarms over thirty miles away on the days immediately following, leaves no question as to the connection between the two. That the species could have bred locally is out of question, because the larval *status* of the pine region was thoroughly known.

At New Brunswick I was materially assisted in the arrangement and preservation of material by Mr. E. L. Dickerson, to whom, also, some special investigations and surveys were instrusted.

Mr. Clarence Van Duersen was laboratory and field assistant during the summer, and made collections in and around New Brunswick, besides looking after the breeding-pails and jars.

As for the writer, his work consisted, first of all, in planning and supervising the work of all the parties already enumerated. I have visited all sections of the State where work has been done, have personally verified some of the observations made, and have, altogether, kept the entire investigation under way along the lines laid out at the beginning of the year. As the campaign must be, for the present, largely educational, to enable the public to understand that control is really possible, it has seemed desirable to assist all communities seeking information to the best of my ability.

Early in the season the Board of Health at Elizabeth began work at the mouth of the Elizabeth river, and Mr. H. H. Brehme was assigned to assist in locating the most virulent breeding-places. During the season of 1902 an active campaign against the local forms had been carried on under the direction of Dr. William F. Robinson, Principal of the Cherry Street Grammar School, and this had prepared the community for the more comprehensive work carried on under the direction of Mr. Louis J. Richards, the Health Inspector. With the details of the work this office had nothing to do; but it may be said that an area of some ninety acres of the nastiest mosquito-breeding ground near the city has been rendered entirely safe at an average cost of less than $8 per acre. Where in the past there was an area of swamp, in which it was difficult to get about even in rubber boots, a series of well-planned spade-wide ditches have produced a meadow that drains completely within forty-eight hours after the heaviest flood, and in which fish can reach every place into which water can come. Most of the work is on the north side of the river, east of the railroad, and the ditches were put in by spade work, at a cost of about 1½ cents per running foot. A smaller area on the west side of the railroad was partly drained by machine ditching, at the rate of 1 cent per running foot. At several periods during the season this ditched area was explored after heavy rains and high tides, and in every instance it was found to be free from mosquito larvæ.

On several occasion during 1902 and the early part of 1903 I sent communications to the Board of Health at Newark concerning the mosquito-breeding areas near that city, and finally a committee was appointed, with Dr. F. W. Becker as Chairman, to look into the matter. Dr. Becker was soon convinced of the feasibility of at least materially reducing the plague, and became an enthusiastic promoter of the work. Through his efforts the board appropriated the sum of $250 for drainage, and, as I considered the matter of very great importance as an object-lesson, I devoted $150 to the same end. Almost 40,000 feet of ditches were cut by the True ditcher, and one of the worst breeding areas immediately adjacent to Newark is almost completely cured. The ditches are six inches wide, full two feet deep, and drain the meadow perfectly in twenty-four hours, no matter how heavy the flood.

The work here done developed a somewhat unexpected difficulty. Ownership of the marsh area is much divided up, and some of the owners objected to the draining of their land, though it was a positive improvement, and added increased value for salt hay—the only thing raised there. It will need authority given to the local boards of health to compel drainage of lands where mosquitoes breed, or at least to compel the owner or occupant to allow them to be drained whenever any authorized body undertakes the work.

The work begun at Newark had a more far-reaching effect than was at first anticipated. Dr. Becker and the Secretary of the board, Mr. David D. Chandler, invited representatives of the boards of health of the surrounding communities to consult on the subject, and the response was so unexpectedly great that a Conference Committee on Mosquito Extermination was organized. This body held several meetings during the summer, and to them I presented in detail results of the investigations made in the communties represented.

Over the work done on the Newark meadows, Mr. H. H. Brehme had a general superintendence, and laid out the main scheme of ditching.

This demonstrates positively—*first,* that salt meadows similar to those at Newark can be readily ditched by machine; *second,* that the ditches so cut drain the land perfectly for the purpose of preventing the development of mosquitoes; *third,* that the narrow, deep ditches are better than broader, more shallow ones; *fourth,* that the

cost is not heavy, and *fifth,* that it is quite feasible to eliminate the salt marsh mosquito entirely on marsh areas than can be ditched.

Some work in the way of mosquito control was done by the Monmouth Beach Improvement Association during 1902, under the direction of Mr. Eugene Winship, and this was greatly extended during 1903. For several days Mr. H. H. Brehme assisted in locating the breeding areas along the Shrewsbury river and on the Government Reservation at Sandy Hook. I went over part of the ground myself and met with a number of the owners at Monmouth Beach and Rumson Neck that were most interested. The work done has been so successful, in spite of disadvantages, that there is little doubt of its being continued until permanent relief is obtained. Owing to the fact that the start was made late and that the funds in hand were not sufficient for draining the bad places, it was necessary to use oil to kill off the larvæ over much of the territory involved. Mr. Winship knows the problem thoroughly and knows the remedy; he can be relied upon to effect a cure if given the opportunity.

A mistake is made by many associations in expecting too much at once for a small outlay. The quickest and most obvious results are, of course, obtainable by using oil on breeding-places to destroy the lravæ, but this is a temporary makeshift and must be repeated as often as a pool becomes repopulated. If this sort of work be kept up during the season the cost will be considerable, and, at the end, conditions will be exactly what they were in the beginning. But every breeding-place drained or filled is a permanent gain, and the work need be done once only. After a season of that sort of work a positive gain has been made and new territory can be taken in hand the season following.

The work done at Beach Haven has been already referred to and the effect was so obvious and so marked that it is certain to be continued and extended next year. Mr. R. F. Engle was the moving spirit in this work, and the part which my assistants took has been already referred to.

Nowhere has better, more thorough and more intelligent work been done than at South Orange, under the supervision of Mr. Spencer Miller. So far as the local problem there is concerned it is almost solved, and most of the work done is permanent in character. Unfortunately, South Orange is within range of the salt-marsh mosquitoes, and there were periods during the past summer when no other species were obvious to the man in the street.

There is also a range of breeding-places on the wooded ridges to the north and west, and from these come one or two other species, at times, in unpleasant numbers. Yet Mr. Miller claims that the local species are the most troublesome, and, on the whole, I believe he is right. Seasons like that of 1903 are rare, and, under ordinary conditions, there would be few swarms of either *C. sollicitans* or *C. cantator* that would reach so far up the slope as South Orange. Nor would such swarms remain more than a few days. Mr. Brehme and Mr. Grossbeck have both collected over the park area, and the Park Commissioners could very materially aid in the mosquito work at very slight cost to themselves and to the decided benefit of the park.

Montclair looks after its problem through the Board of Health, of which Mr. H. N. Parker is Secretary and health officer, and he thoroughly understands what is to be done.

At all the points mentioned I have met with the parties interested, and at many other places I have spoken before improvement societies, councils, Boards of Health and other bodies, whom I sought to interest in the practical work. Real progress has been made, and I feel certain that when once any community has realized that there is actually a possibility of abating the mosquito pest, it will, sooner or later, do the required work.

An important experiment to answer a question was made at New Brunswick under difficulties. Assuming that the common house mosquito, *Culex pungens,* does not travel far from its breeding-place, can a limited area in a city be kept free if no work is done in other parts of it? The Sixth ward, in which my residence is situated, has some bad breeding-places in open lots, stagnant gutters and sewer catch-basins. In the gutters, sewer basins and most of the lot pools, *Culex pungens* breeds abundantly and *C. restuans* rarely. Late in the summer *Anopheles punctipennis* occurs in small numbers in the lot pools. In my pails I bred the same species continuously during the summer. In one large depression, *Culex sylvestris* occured after mid-summer in startling quantities.

Beginning late in May, because at that time larvæ first began to mature in my pails, all probable breeding-places were thoroughly sprinkled at about ten-day intervals with diluted chloronaptholeum by the deputy inspector of the Board of Health, until they were milky throughout. Until the beginning of July there were very few mosquitoes on my front porch, and we may be said to have been practi-

cally free. During the first days of July a small brood of *C. sollicitans* and a very heavy brood of *C. cantator* came in from the Amboy meadows, and these were supplemented at short intervals by new arrivals, so that, until late August, the shore mosquitoes simply dominated the situation. To determine this fact, collections were made on my piazza in the early evening at frequent intervals—nightly for some time—and the specimens captured were counted and determined. Not 1 per cent. of those taken were locals, and some nights not one local was taken. In other words, but for the shore species that bred on the Amboy meadows, there would have been no trouble with mosquitoes at my house. This was emphasized by the fact that we had none indoors, the salt-marsh species rarely attempting to enter the house.

The experiment proves that, were it not for the migrant species, *C. sollicitans* and *C. cantator,* the New Brunswick mosquito problem would be of the simplest kind and easily solved. It further proves that one section of the city might keep its own territory free, with advantage to its inhabitants, though other sections might remain badly infested. This feature is an important one in many of our municipalities, and, away from the influence of the shore, makes satisfactory work in a limited territory possible.

It should be added, perhaps, that the treated places were kept under close observation, so that I knew positively that there great numbers of larvæ present before treatment was made, and also that they were killed by the treatment. In one or two instances treatment was delayed until some had reached the pupa stage, and it is probable that a few adults emerged, since the pupæ are very strongly resistant to insecticides.

An interesting feature of the summer's observations, to which brief reference was previously made, was the discovery that a very large percentage of the adults of the ring-legged salt marsh mosquito, *Culex sollicitans,* developing at points south of the Raritan river, were infested by an intestinal worm, which has been named *Agamomermis culicis* by Dr. Charles Wardell Stiles, of the United States Marine Hospital Service. A few specimens of this parasite were noted in 1902, and two of them were preserved and sent to Dr. Stiles, who is a specialist in this group. They were not determined until the spring of 1903, just before I discovered the presence of the parasite in a considerable percentage of mosquitoes taken in the Barnegat Bay

district. At about the same time Mr. Viereck reported from Cape May that as many as 80 per cent. of some captures proved to be infested in the same way, and that the worm was undoubtedly a factor in keeping down the insects. Especial attention was then paid to the subject, and it appeared that the parasite did not occur in any captures made in either the Newark or Elizabeth meadows and only sparingly in the Amboy district. From this point south it increased in numbers, until the large percentage found at Cape May was reached.

Unfortunately the percentage of infestation was not equally high for all the broods, and some of them seemed almost exempt after midsummer. The latest series of mosquitoes were again parasitized almost to the point of extinction.

Some correspondence was had with Dr. Stiles looking to a study of the parasite by his department of the United States Marine Hospital Service, but, for a variety of reasons, it was deemed inexpedient to make it during the current year (1903). During October I called upon the Surgeon-General, Dr. Walter Wyman, in company with Dr. Stiles, and presented the subject to him personally. It is probable now that Dr. Stiles will be detailed to make the investigation needed to determine whether the parasite can be made economically useful in sections where, for any reason, drainage or similar methods are impossible or inadvisable.

As to the effect of the worm upon the mosquito, it neither prevents it from biting nor from migrating, but it does prevent it from reproducing its kind. In no case were the ovaries developed in a wormy insect, and, when the worms reached their full growth, nothing remained of the abdomen but the outer shell. As every female mosquito of the salt-marsh species is capable of laying nearly or quite 200 eggs, the effect of a parasite which destroys 80 per cent. of them is easily appreciated, and, if it possible to make any use of it whatever, no effort should be spared to determine how it may be done.

Altogether the progress made is satisfactory. So many problems have been cleared up during the past season that the work for 1904 is much simplified. A great deal yet remains to be done before the investigation can be said to be completed, but there seems to be no reason at present why the work as originally planned cannot be done by the end of next year and reported upon in detail.

The following is a list of the species thus far taken in the State, and those that are starred (*) have been bred from the larva:

*Sayomyia albipes *Johann.*
*Corethra cinctipes *Coq.*
*Corethrella brakeleyi *Coq.*
*Anopheles punctipennis *Say.*
* " maculipennis *Meig.*
* " crucians *Wied.*
*Conchyliastes musicus *Say.*
*Psorophora ciliata *Fabr.*
*Culex triseriatus *Say.*
* " signifer *Coq.*
* " serratus *Theob.*
* " dupreei *Coq.*
* " trivittatus *Coq.*
* " aurifer *Coq.*
* " reptans *Wlk.*
" squamiger *Coq.*
* " sollicitans *Wlk.*
* " tæniorhynchus *Wied.*
* " jamaicensis *Theob.*
" perturbans *Wlk.*
* " canadensis *Theob.*
* " cantator *Coq.*
* " cantans *Meig.*
* " sylvestris *Theob.*
* " discolor *Coq.*
* " melanurus *Coq.*
* " pipiens *Linn.* (pungens *Wied.*)
* " restuans *Theob.*
* " nigritulus *Wlk.*
* " territans *Wlk.*
*Uranotænia saphirina *O-S.*
*Wyeomyia smithii *Coq.*
*Aedes fuscus *O-S.*